Introduction to Neuropsychology Notes

Neuropsychology (Christ (Deemed To Be University))

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Introduction to Neuropsychology_

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https://youtu.be/OZG8M_ldA1M

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Verbal

Wisconsin Card sorting Test: Set shifting (Starting from 1:34:40 in the 16th video)

Tower of London: Planning

Stroop test: Response inhibition

Token Test: Comprehension

AVLT: Auditory Verbal Learning Test: Verbal Memory (Attributed to the left temporal lobe)

Complex Figure Test: Visual memory, Visual-spatial construction (Tests damage to the right temporal lobe)

Neuropsychological Rehabilitation

Cognitive Reserve:

Neuroplasticity:

2 protocols to understand the extent of damage:

Plan of recovery.

Examples of cognitive rehabilitation tasks

CogSMART protocols

So this is what happens during rehabilitation:

Neurofeedback:

Unit 1

Introduction

- **Definition** - The scientific study of the relations between brain function and behavior.
- Neuropsychology draws information from many disciplines—anatomy, biology, biophysics, ethology, pharmacology, physiology, physiological psychology, and philosophy among them.
- Neuropsychological investigations into the brain–behavior relationship can identify impairments in behavior that result from brain trauma and from diseases that affect the brain.
- Neuropsychology is strongly influenced by two experimental and theoretical investigations into brain function:
    - The **brain theory**, which states that the brain is the source of behavior;
    - The **neuron theory**, the idea that the unit of brain structure and function is the neuron, or nerve cell.

Nature and scope

- The human brain is a fascinating and enigmatic machine.
- Weighing only about 3 pounds (1.36 kilograms) and with a volume of about 1,250 cubic centimeters, it has the ability to monitor and control our basic life support systems, to maintain our posture and direct our movements, to receive and interpret information about the world around us, and to store information in a readily accessible form throughout our lives.
- It allows us to solve problems that range from the strictly practical to the highly abstract, to communicate with our fellow human beings through language, to create new ideas and imagine things that have never existed, to feel love and happiness and disappointment, and to experience an awareness of ourselves as individuals.
- Not only can the brain undertake such a variety of different functions, but it can do more or less all of them simultaneously.

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- How this is achieved is one of the most challenging and exciting problems faced by contemporary science.
- Nevertheless, very considerable advances have been made in neuroscience over the last decade or two, and there is growing confidence among neuroscientists that a real understanding is beginning to emerge.
- Neuropsychology, as one of the neurosciences, has grown to be a separate field of specialization within psychology over about the last 40 years.
- What mechanisms are responsible for human thinking, learning, and emotion, how do these mechanisms operate, and what are the effects of changes in brain states upon human behavior? There are a variety of ways in which neuropsychologists conduct their investigations into such questions.
- A psychology without any reference to physiology can hardly be complete.

Fundamental Concepts

Localization of a function

- The first general theory to propose that **different parts** of the brain have **different functions** was developed in the early 1800s.
- They suggested, the cortex sends instructions to the spinal cord to command muscles to move.
- He developed his hypothesis, called localization of function, that a different, specific brain area controls each kind of behavior.

Lateralization of a function

- A now legendary chain of observations and speculations led to confirmation that language is both localized in the brain and lateralized, that is, located on one side of the brain.
- This discovery led to the principle of lateralization of function, that **one cerebral hemisphere** can perform a **function not shared by the other**.

Neuroplasticity

- In the nineteenth century, the work of French physiologist Pierre Flouren (1794–1867) and, later, the German physiologist Friedrich L. Goltz (1834– 1902) once again challenged the idea that brain functions are localized.
- Both men created animal models of human clinical cases by removing small regions of the cortex.
- Both expected that the animals would lose specific functions.
- Flourens found instead that with the passage of time, his animals recovered from their initial impairments to the point that they seemed to behave typically.
- Thus, an impaired pigeon that would not initially eat or fly with time recovered both abilities.
- Although impaired, its recovered abilities clearly suggested that the remaining brainstem could substitute for the cortex.
- These early experiments actually built the foundation for neuropsychology emphases on recovery of function and on promoting **recovery by rehabilitation after brain damage**, even in extreme circumstances.
- Neuropsychologists recognize that, although all function may not be recovered after injury, the brain's plasticity can be harnessed to produce significant functional improvements.

Approaches to understanding the brain

Structural

When you look at what part of the brain is hurt in understanding trauma. fMRi is an example of a structural study of the brain. Depth of the injury is gauged. More tangible. Core areas of the brain and nervous system including spinal cord are usually studied using this approach.

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Functional

What functions are impaired, for more abstract functions such as memory, planning, emotions that are not as blatantly visible as the amygdala or the lobes. Functional damage can occur without structural damage. Psychological factors can also cause functional damage. Inferential study.

History and branches

History

- Many primitive societies, and even some more developed societies, have from early time practiced the trepanning of skulls, although the evidence is usually in the form of artifacts and in human remains.
- There is an Egyptian papyrus dating from about 2500 B.C. that reports on some cases of trauma to the brain.

Trepanation

- Large or small openings are made in the skull that may or may not be subsequently repaired.
- Magico Religious explanations.
- Witch doctors conducted it.

For more information: https://www.researchgate.net/publication/272836505_Trepanation_or_Complete_Removal_of_the_Outer_Table_of_the_Calvarium_for_Granulation_Induction_The_ErbiumYAG_Laser_as_an_Alternative_to_the_Rose_Head_Burr

(P.S - Got creepy and weird images that'll probably stay on your mind for a while)

Phrenology

Development of the various mental faculties was associated with development of certain areas of the brain, and that this in turn was reflected in bumps on the skull overlying the relevant area.

- Gall and Spurzheim identified a long list of behavioral traits borrowed from the English or Scottish psychology of the time.
- They assigned each trait to a particular part of the skull and, by inference, to the underlying brain part.
- Spurzheim called this study of the **relation between the skull's surface features** and a **person's mental faculties** phrenology (phren is a Greek word for "mind").
- Some people seized on phrenology as a means of making personality assessments.
- They developed a method called *cranioscopy*, in which a device was placed around the skull to measure its bumps and depressions.
- These measures were then correlated with the phrenological map to determine the person's likely behavioral traits.

Disadvantages:

- The faculties described in phrenology— characteristics such as faith, self-love, and veneration —are impossible to define and to quantify objectively.
- Phrenologists also failed to recognize that the superficial features on the skull reveal little about the underlying brain.

- Gall's notion of localization of function, although inaccurate scientifically, laid the conceptual foundation for modern views of functional localization, beginning with the localization of

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language.

- *Case study* : On the origins of organology: Franz Joseph Gall and a girl named Bianchi.

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Cortex

Volume 86, January 2017, Pages 123-131

Historical paper

On the origins of organology: Franz Joseph Gall and a girl named Bianchi

Paul Eling [a], Stanley Finger [b], Harry Whitaker [c]

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https://doi.org/10.1016/j.cortex.2016.11.010

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Abstract

Franz Joseph Gall (1758–1828) introduced a new theory of mind and brain at the end of the eighteenth century, which he referred to as organology, dealing with mental functions and their cortical localizations. Gall wrote that observations regarding the verbal learning capacities of his schoolmates brought about his new way of thinking. This widely accepted view, however, requires qualification. Although Gall's experiences and observations as a schoolboy were relevant, especially for his craniology, these childhood memories might have been recalled and reinterpreted *after* he had started to think about the faculties of mind—specifically after he had met Bianchi, a 5-year-old girl with a special talent for music.

Table 1.
with summary of the history of discovery of the 27 faculties of Gall.

Faculty [a]	History of Discovery
I. Instinct of generation, of reproduction; instinct of propagation, &c.	Gall had a patient, a widow suffering from hysterical attacks with very warm regions in the neck. She told Gall that she had felt this heat from an early age on, whenever she felt certain desires.
II. Love of offspring	During a lecture he realized the analogy between skulls of monkeys and women. This happened 'many years' after he had started to determine faculties.
III. Attachment. Friendship.	A woman was brought to Gall, said to be the model of friendship, he made a cast of her head and noticed two prominences next to the faculty for love of offspring.
IV. Instinct of self-defence, disposition to quarrel, courage (Muth, Raufsinn)	Quarrelsome vs peacable individuals in his meetings at his house with ordinary people.
V. Carnivorous instinct; disposition to murder (Wurgsinn)	He compared skulls of frugivorous and carnivorous animals. He later received skulls from murderers and noticed similarity.
VI. Cunning, trick, tact, (List, Schlauheit, Kluheit)	'In early youth, I was struck with the character and form of the head of one of my companions, who, with amiable dispositions and good abilities, was distinguished for cunning and trickery.'
VII. Sense of property, instinct of providing, covetousness, propensity to steal (Eigenthumssinn, Hang zu Stehlen)	'When I could assemble a considerable number, I would often divide them into three classes. The first would include the chipeurs; the second, those who had an abhorrence of theft; and the third, those who regard it with indifference.'
VIII. Pride, hauteur, loftiness, elevation (Stolz, Hochmdh, Herschsucht)	A beggar attracted his attention, he noticed a prominence that he could not interpret and questioned the beggar.
IX. Vanity, ambition, love of glory (Eitelkeit, Ruhmsucht, Ehrgeitz)	Working in the insane hospital, establishing the discovery of the organ of pride, he met a woman who imagined herself to be the Queen of France. He then corrected his ideas about pride and vanity.
X. Cautiousness, foresight (Behutsamkeit, Vorsicht, Vorsichtigkeit)	At Vienna he met with a prelate of excellent sense, very cautious. Sitting behind this man and the Councilor of the Regency with a nickname Cacadubio, Gall noticed the features.

In the 1800s brain localization theories were the popular theories on how the brain functioned.

Localizationist theory

- Assigned a specific function to a precise part or location of the brain, and it had moderate, although not unqualified, success.
- The theories put forward by Broca and Wernike support this theory.

Equipotential theory

- Sensory input may be localized, perception involves the whole brain, and the effects of brain lesions depend not upon their location but upon their extent.
- It is a balance between localisation and generalisation theories.
- For example sensation is localised but perception is generalised.

Interactionist theory

- Higher functions are built up from a number of more basic component skills.
- These component skills are relatively localized, but because of the potential variety of complex ways in which the skills are linked to form intelligent functions, the higher-level behavior does not necessarily appear to be localized.

Branches

- Neuropsychology is often divided into two main areas: **clinical neuropsychology** and **experimental neuropsychology.**

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Clinical neuropsychology

- Deals with patients who have **lesions of the brain**.
- These lesions may be the effects of disease or tumors, may result from physical damage or trauma to the brain, or be the result of other biochemical changes, perhaps caused by toxic substances.
- The clinical neuropsychologist measures deficits in intelligence, personality, and sensory–motor functions by specialized testing procedures, and relates the results to the particular areas of the brain that have been affected.
- Clinical neuropsychologists employ these measurements not only in the scientific investigation of brain–behavior relationships, but also in the practical clinical work of aiding diagnosis of brain lesions and rehabilitating brain-injured patients.

Experimental neuropsychology

- By contrast, experimental neuropsychologists work with **normal subjects** with **intact brains**.
- This is the most recent area of neuropsychology to develop and has grown rapidly since the 1960s, with the invention of a variety of techniques that can be employed in the laboratory to study higher functions in the brain.
- Subjects are generally required to undertake performance tasks while their accuracy or speed of response is recorded, from which inferences about brain organization can be made.

Methods in Neuroscience/ Methods of study of research in neuropsychology-Neurohistology

Neuroimaging methods

X Ray based techniques

Contrast X Rays

- Contrast x-ray techniques involve injecting into one compartment of the body a **substance that absorbs x-rays** either less than or more than the surrounding tissue.
- One contrast X-ray technique, **Cerebral angiography**, uses the infusion of a radio opaque dye into a cerebral artery to visualize the cerebral circulatory system during x-ray photography (a method for imaging blood vessels)
- They are most useful for localizing **vascular damage.**

Computed Tomography (CT)

- A computer-assisted x-ray procedure that can be used to visualize the brain and other internal structures
- The **x-ray tube** and **detector** automatically **rotate around the head** of the patient at one level of the brain, taking many individual x ray photographs as they rotate
- It involves passing a narrow X-ray beam through the **same object at many angles**, creating many images.
- Scans of eight or nine horizontal brain sections are typically obtained from a patient, when combined, they can provide a **three dimensional representation of the brain**.
- X-rays are absorbed less by fluid than by brain cells and less by brain cells than by bone.
- Brain injury can be visualized, because **dead cells** in the injured area produce a **darker image** on the scan than do healthy, living brain cells that contain less water.

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- The CT resolution is sufficient for localizing brain tumors and lesions.
- CT scans can be obtained quickly and cheaply.

Radioactivity based techniques

Positron Emission Tomography (PET)

- The first functional brain imaging technique (Provided images of brain activity rather than brain structure).
- Radioactive **fluorodeoxyglucose (FDg)** is injected into the patient's **carotid artery.**
- Because of its similarity to glucose, fluorodeoxyglucose is rapidly taken up by active (energy-consuming) cells.
- However, unlike glucose, fluorodeoxyglucose cannot be metabolized; it therefore **accumulates in active neurons.**
- As the radioactivity decays, it **gives off photons**, allowing a computer to draw their location on a two- or three-dimensional reconstruction of the brain.
- For example, if a PET scan is taken of a patient who engages in an activity such as reading for about 30 seconds after FDg injection, the resulting scan will indicate the areas of the target brain that were most active during the 30 seconds.
- PET scans is merely a **colored map** indicating radioactivity in the brain
- PET can image many chemicals; thus, diseases characterized by chemical changes can be imaged.
- PET is widely used to **study cognitive function** (speaking, reading, and writing).

Magnetic Field based techniques

Magnetic Resonance Imaging (MRI)

- A large magnet (M) and a specific radiofrequency pulse (R) generate a brain signal that produces an image (I).
- MRI is used to study both brain anatomy and neural function **noninvasively** and because it does not make use of ionizing radiation, it is **safe enough to use repeatedly** on volunteers and patients, adult and child alike.
- Structural brain-imaging procedure in which high-resolution images are constructed from the measurement of **radio-frequency waves** that hydrogen atoms emit as they align with a powerful magnetic field.
- Calculates the location of moving molecules by detecting the electrical charge their movement generates.
- In other words, the Hydrogen atoms (protons) behave like a compass needle that aligns itself north and south with Earth's magnetic field.
- When aligned, the protons' summed electrical current is large enough to be measured.
- Because proton density varies in different brain tissue (cerebrospinal fluid, myelin, neurons), largely in proportion to its water content, the electrical currents produced by the aligned protons are different, higher for some tissues and lower for others.
- MRI can use regional differences to reveal excellent brain images.
- MRI can also determine the relative concentrations of oxygen and carbon dioxide
- The high resolution of MRIs can create lifelike images of the brain and provide excellent detail of brain areas active during particular behaviors. (Better than CT)

Diffusion tensor imaging (DTI)

- An MRI method that detects the directional movements of water

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molecules to create virtual images of the brain's nerve fiber pathways.
- Because tracts (bundles of axon) are the major routes of water diffusion.

Functional MRI

- Functional Mri (fMri) produces images representing the **increase in oxygen flow** in the **blood** to **active areas of the brain.**
- Active areas of the brain take up more oxygenated blood whereas **damaged brain** areas use **less oxygen**.
- The signal recorded by fMRI is called **BOLD** signal (Blood-oxygen-level dependent signal)
- It can be used to determine regional differences in brain activity.
- It is used to even communicate with patients in a "***vegetative state***" (patients who appear to lack consciousness).
- fMRI has four advantages over PET:
    - Nothing has to be injected into the volunteer.
    - It provides both structural and functional information in the same image
    - It has better spatial resolution.
    - It can be used to provide three dimensional images of activity over the entire brain

Transcranial Stimulation

- Transcranial magnetic stimulation (tMS) is a technique that can be used to turn off an area of the human cortex by creating a magnetic field under a coil positioned next to the skull.
- High-voltage current is passed through the coil in pulses as rapid as 50 times per second.
- Each electrical pulse produces a rapid increase, then a decrease, in the magnetic field around the coil.
- The magnetic field penetrates the skull and changes the electrical activity of adjacent neurons
- The magnetic field temporarily turns off a part of the human brain while the effects of disruption on cognition and behaviour are assessed.
- TMS was originally used by neurosurgeons for stimulating brain tissue, both to monitor its functioning during brain surgery and to identify the tissue's function.
- From this initial use, it became clear that TMS does not harm brain tissue, even after thousands of pulses of stimulation, and so can be used to stimulate healthy brains through the skull.
- Repetitive TMS (rTMS) pulses can inactivate an area of brain tissue for a short time, allowing a TMS researcher to make a temporary virtual lesion in the brain and study its consequences.
- Also used as an intervention technique

Psycho-pshysiological methods

Electroencephalography

- In the early 1930s, German physiologist Hans Berger developed a technique for recording electrical activity over large regions of the human brain.
- The electroencephalogram (EEG) is a measure of the gross electrical activity of the brain.
- It is recorded through large electrodes by a device called an electroencephalograph (EEG

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machine)

- In a traditional EEG recording arrangement, one electrode (a small metal disc called the active electrode) is attached or pasted to the scalp to detect the electrical activity in the underlying brain area.
- A second electrode (the indifferent electrode) is attached elsewhere, on the earlobe perhaps, where no changing electrical activity exists.
- The two electrodes detect the difference in electrical potentials near the scalp electrode, thus revealing the underlying brain activity.
- The EEG is a valuable tool for studying states of consciousness, including waking, sleep, and anesthesia; for diagnosing epilepsy and brain damage; and for studying cognitive functions

Electromyography

- The usual procedure for measuring muscle tension.
- The activity is usually recorded between two electrodes taped to the surface of the skin over the muscle of interest.
- The resulting record is called an **electromyogram** (EMG)

Electrooculography

- The electrophysiological technique for recording eye movements.
- A steady potential difference exists between the front (positive) and back (negative) of the eyeball.
- Because of this steady potential, when the eye moves, a change in the electrical potential between electrodes placed around the eye can be recorded.
- The resulting record is called an **electrooculogram** (EOG).

Electrodermal activity

- The two most commonly employed indexes of electrodermal activity are the **skin conductance level (SCL)** and the **skin conductance response (SCr)**.
- The SCL is a measure of the background level of skin conductance that is associated with a particular situation, whereas the SCR is a measure of the transient changes in skin conductance that are associated with discrete experiences.

Invasive methods

Stereotaxic Surgery

- Stereotaxic surgery is the means by which experimental devices are precisely positioned in the depths of the brain.
- Two things are required in stereotaxic surgery: an atlas to provide directions to the target site and an instrument for getting there.
- The **stereotaxic atlas** is used to locate brain structures in much the same way that geographic atlas is used to locate landmarks on Earth.
- Since, the brain is 3 dimensional, it is represented by a series of individual maps, one per page, each representing the structure of a single, two dimensional frontal brain slice.
- The **stereotaxic instrument** has two parts: *a head holder*, which firmly holds each subject's brain in the prescribed position and orientation and an *electrode holder*, which holds the device to be inserted.

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Lesions

Aspirational Lesion

- When a lesion is to be made in an area of cortical tissue that is accessible to the eyes and instruments of the surgeon, aspiration is frequently the method of choice.

Radio-frequency lesions

- Small subcortical lesions are commonly made by passing radio-frequency current (high frequency current) through the target tissue from the tip of a stereotaxically positioned electrode

Knife cuts

- Sectioning (cutting) is used to eliminate conduction in a nerve or tract.

Reversible lesions

- Reversible lesions are methods for temporarily eliminating the activity in a particular area of the brain while tests are being conducted.
- The advantage of reversible lesions is that the same subjects can be repeatedly tested in both the lesion and control conditions.
- Reversible lesions can be produced by cooling the target structure or by injecting an anesthetic

Electrical Stimulation

Intracellular Unit Recording

- It is an invasive method where moment-by-moment of graded fluctuation in a neuron's membrane is recorded.
- An intracellular microelectrode is positioned inside a neuron to record the membrane potential as it fires.
- It is performed on chemically immobilized animals only.

Extracellular Unit Recording

- The action potential of a neuron is recorded by placing the tip of microelectrode next to it in the extracellular fluid.
- The electrical disturbance caused by a neuron's firing is recorded. Although this does not provide any information about the membrane potential of the neuron.
- Initially extracellular recording was limited to just one neuron at a time due to the free movement of the microelectrode. But, now with the help of a special flexible microelectrode about 100 neurons can be recorded simultaneously.

Multiple Unit Recording

- The electrode tip is larger and is able to pick up signals from many neurons.
- The signals from all these action potentials are then added up in an integrating circuit which produces a multiple unit recording graph.

Invasive EEG Recording

- Large electrodes are implanted in animals to record EEG signals.
- Cortical EEG signals are recorded through stainless steel skull screws whereas subcortical EEG signals are recorded through stereotaxically implanted wire electrodes.

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Neuropsychological Assessments

Batteries versus Screening tools

- Battery is a comprehensive set of assessment. It is very detailed and is time consuming. Whereas a screening tool is quicker and gives a brief overview of impaired functions.
- Battery is time and cost intensive whereas a screening tool is not.
- Screening helps us plan interventions and gives us an idea of what kind of battery we need to test this further.

- Reliability - is the consistency of an answer to a relatively stable concept. For example, if a person weighs themselves during the course of a day they would expect to see a similar reading.
- Validity - the extent to which a test is measuring what it claims to measure. For example a test of intelligence should measure intelligence and not something else (such as memory)
- Norms - are standards or a yardstick used to measure performance based on certain factors such as cultural factors of demographic factors to interpret test scores

- **Culture-fair tests**, also called **culture-free tests**, are designed to assess intelligence (or other attributes) without relying on knowledge specific to any individual **cultural** group. Paul Echman's test that can be applied to all or most cultures based on literacy. It is called the microexpression test.

Screening Tools

The Addenbrooke's Cognitive Examination

- So, this is the one we did as a part of our asynchronous activity. The one in which we had to administer the test to a client. Here's the link to the test:
- https://www.sydney.edu.au/content/dam/corporate/documents/brain-and-mind-centre/ace-111-updates/india-translations/ace-iii_indianenglish_version.pdf
- It is a clinician administered test. Participant isn't given the test, the clinician fills in the answers.
- The maximum score given is 100. Anyone that scores below 70 has mild cognitive impairment and anyone below 62 has major impairment according to indian standards.

The Mini Mental Status Examination

- It has 30 questions. Based on similar criteria as the ACE
    - The examiner has a degree of freedom to choose particulars of the questions such as the words for the memory test.
    - Also has an alternatives for the mathematics questions
    - Interpretations - primarily developed to measures dementia
    - <24 - abnormal (27 is now the cut off. Range between 24-27 mild impairments)

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Batteries

Nimhans Neuropsychological Assessment Battery

- The domains as are follows
    - **a. Speed**
        - i. Motor speed - finger tapping test
        - ii. Mental speed - Digit substitution test
    - **b. Attention**
        - i. Focused attention - Color trails : 1-25 numbers are arranged across the screen needs and the individual needs to point to the numbers.
        - ii. Sustained attention - Digit Vigilance test : The individual needs to persist their attention in picking out two numbers from a random ordered grid.
        - iii. Divided attention - Triads test
    - **c. Executive Functions**
        - i. Verbal fluency - Controlled oral word association
        - ii. Category Fluency - Animal names test
        - iii. Design Fluency - Design fluency test
        - iv. Working memory - N Back (visual & verbal)
        - v. Set Shifting - Wisconsin Card Sorting Test
        - vi. Response Inhibition - Stroop
        - vii. Planning - Tower of London
    - **d. Comprehension**
        - i. Verbal comprehension - Token test
    - **e. Learning and memory**
        - i. Verbal - Ray’s Auditory verbal Learning test
        - ii. Visual - Complex figure test
    - **f. Visuo-spatial Construction** -
        - i. Complex figure test

Unit 2

Developmental Neuropsychology

Devoted to exploring relationships between brain and behavior across the life span

Neuropsychology of mental development

Neurogenesis and Anatomy of a Neuron

- Alongside the idea that the brain is responsible for all behavior, the second major source of findings

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that influences modern neuropsychology is the **neuron theory**, the idea that the unit of brain structure and function is the **nerve cell**.

- In this section, we introduce the three aspects of the neuron theory:
    - (1) neurons are discrete, autonomous cells that interact but are not physically connected
    - (2) neurons send electrical signals that have a chemical basis
    - (3) neurons use chemical signals to communicate with one another.

Cells of the nervous system

- The nervous system is composed of two classes of cells, **neurons and glia**.
- The human nervous system contains about 85 billion neurons and 86 billion glial cells.

1. Nerve cells (neurons)

Neurons produce our behavior and mediate the brain's plasticity, allowing us to learn and adapt.

- Basic structural units of the nervous system
- Specific, unique kinds of cells in our bodies that carry information through electrical and chemical signals.
- Rate of neuron growth during development of a fetus (in the womb) is about 250,000 neurons/minute
- The human brain has about 84 billion (84,000,000,000) neurons.
- So, if we line up 84 billion neurons the line will stretch to about 1000 km

The birth of a neuron:

- The brain originates in a single, undifferentiated neural stem cell (a germinal cell).
- Self-renewing multipotential neural stem cells give rise to the different types of neurons and glia in the nervous system.
- Majority of neurons are present at birth
- However, neurons can be lost after birth during typical development.
- In the adult brain, stem cells that persist can produce new neurons in some brain locations (Adult neurogenesis)

2. Supporting cells (glia)

Glial cells help the neurons out, **holding them together** (some do act as glue) and providing other support functions, such as **delivering nutrients** and **removing waste**. The various types of glial cells have different functions as well. Five types of glia are described here:

■ Astrocytes

These **star shaped** cells are a prominent type of glia in the brain, performing a number of supporting functions for the neurons.

- Mechanical(Structural) support
- Metabolic (nutrition) support
- Encapsulate synapses
- Regulate chemical and ionic environment
- Form scar tissue
- Act as phagocytes
- Transport nutrients and wastes

Note: Phagocytes are cells that protect the body by ingesting harmful foreign particles, bacteria, and dead or dying cells.

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■ Microglia

- Act as phagocytes
- Remove debris
- Part of brain's immune system

■ Oligodendrocytes

- Asymmetrical
- Myelinate axons of central nervous system (insulate neurons in the CNS)

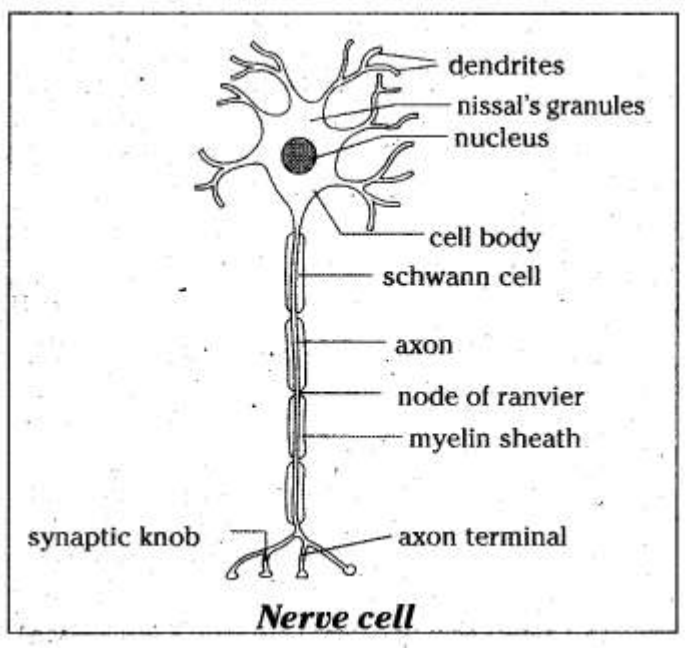
■ Schwann Cells

- Myelinate axons of peripheral nervous system

● Ependymal cells

- Line the brain's ventricles and make CSF (CerebroSpinalFluid)

Structure of a Neuron



1. Soma

- The core region is called the cell body, or soma.
- Consists of the nucleus & much of the machinery needed for the life processes of the cell.
- Shape & size vary.

2. Dendrites

- Branching extensions.
- A neuron may have from 1 to 20 or more dendrites, each of which may have one or many branches.
- The dendrites and axon are extensions of the neuron's cell body, enlarging the cell's surface area to increase its interactions with other cells.
- Important recipients of messages.

3. Axon

- Each neuron has a **single axon** that may branch into axon collaterals.
- The axon collaterals may divide into a number of smaller branches called telodendria

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("end branches") before contacting the dendrites of another neuron.

- Long slender tube covered by a Myelin Sheath.
- Carries messages to the terminal buttons.

4. Myelin Sheath

- Fatty material made by glial cells.
- Insulates the axon.
- Allows for rapid movement of electrical impulses along the axon.

5. Nodes of Ranvier

- Gaps in myelin sheath where action potentials are transmitted.
- Multiple sclerosis is a breakdown of myelin sheath.
- Speed of neural impulse Ranges from 2 – 200+ mph.

6. Terminal Buttons

- At the end of each telodendria is a knob called an end foot, or terminal button.
- Secrete **neurotransmitters** when an action potential reaches them.
- The terminal button sits very close to a dendritic spine on another neuron, although it does not touch that spine.
- This "almost connection" between the surface of the axon's end foot and the corresponding surface of the neighboring dendritic spine plus the space between the two is the **synapse**.

Classification/Types of Neurons

The classification of Neurons is done based on the:

1. Function
2. Structure

1. Function

Sensory neurons

- The simplest sensory receptor.
- A cell that transduces sensory information into nervous system activity - is the bipolar neuron.
- It consists of a cell body with a dendrite on one side and an axon on the other and is found in the retina of the eye.
- A somatosensory neuron projects from a sensory receptor in the body into the spinal cord.
- Its dendrite and axon are connected, which speeds information conduction because messages do not have to pass through the cell body.

Motor neurons

- Motor neurons located in the brainstem and spinal cord project to facial and body muscles.
- Together, motor neurons are called "the final common path" because all behavior (movement) produced by the brain is produced through them.

Interneurons

- Interneurons within the brain and spinal cord link up sensory- and motor-neuron activity in the CNS.

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- The many kinds of interneurons all have multiple dendrites that branch extensively but like all neurons, a brain or spinal-cord interneuron has only one axon (although it can branch).
- Interneurons include stellate (star-shaped) cells characterized by many branches, pyramidal cells in the cortex that have a pyramid-shaped cell body, and Purkinje cells of the cerebellum.

2. Structure

- Unipolar
- Bipolar
- Multipolar

Communication within and among neuron

- Electrochemical in nature.
- Electrically charged ions.
- Sodium (Na), Potassium (K): **Positively charged**
- Chlorine (Cl), Anions: **Negatively charged**
- Semipermeable membrane separates intra & extracellular regions.
- **Refractory period** : during this period irrespective how strong the message is the neuron will not be able to communicate with the adjacent neurons.
- **All or none law** : states that the actional potential either occurs or does not occur at all after reaching a particular threshold.

Resting Potential

- When a neuron is at rest, the inside of the neuron is **negative** relative to the outside (0 Mv).
- Intracellular region: Potassium, Anions
- Extracellular region: Sodium, Chloride
- The summed charges of the unequally distributed ions give the inside of the membrane a charge of **-70 mV** relative to the outside.
- This charge is the membrane's **resting potential**.
- The resting potential is not identical on every axon.
- It can vary from **-40 mV to -90 mV** on axons of different animal species.
- The resting potential represents a store of energy that can change.
- The resting potential can increase or decrease, as you might deposit or withdraw from your bank account, thus increasing or decreasing your potential to spend.

Just read through (not very impt): Slight decreases or increases in an axon's membrane voltage are **graded potentials**, highly localized and restricted to the vicinity on the axon where they are produced. A decrease in the voltage on the membrane is termed **depolarization**, and an increase is termed **hyperpolarization.**

Action Potential

https://youtu.be/OZG8M_ldA1M

- An action potential occurs when a neuron sends information down an axon, away from the cell body.
- Action potentials are caused when different ions cross the neuron membrane.
- An action potential is triggered when the cell membrane is depolarized to about -50 mV.
- Sodium Potassium Pump

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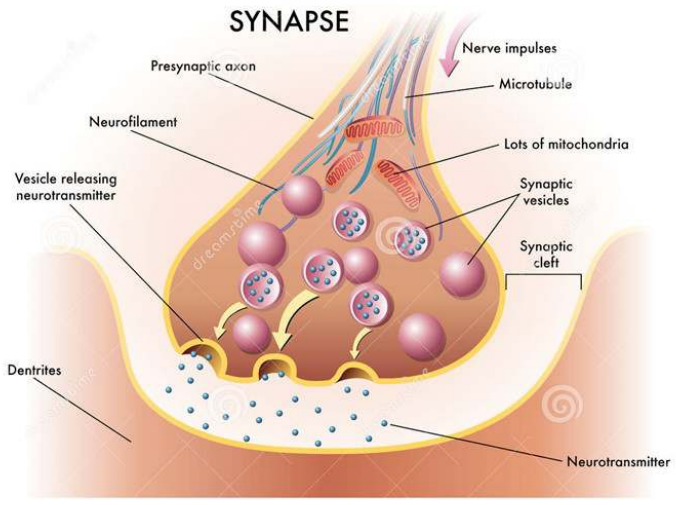
- After the reversal, the membrane gradually returns to its resting potential at -70 mV.
- **Force of diffusion:** Movement of molecules from regions of high concentration to regions of low concentration.
- **Electrostatic force:** Particles with the same charge repel each other.

Synaptic Communication

- The three main parts of a synapse are an axon terminal, the membrane encasing the tip of an adjacent dendritic spine, and the minute space separating the structures—the synaptic cleft.
- On the tip of the dendritic spine is the postsynaptic membrane.
- The patch of dark material within it consists largely of protein molecules specialized for receiving chemical messages.
- The dark patches in the presynaptic membrane—the membrane of the axon terminal—consist largely of protein molecules, most of them serving as channels and pumps and as receptor sites.
- Within the axon terminal are many other specialized structures, including mitochondria (the organelles that supply the cell's energy needs); round granules called synaptic vesicles, which contain the chemical neurotransmitter; and tubules that give the terminal button its shape.
- In some axon terminals, larger storage granules hold a number of synaptic vesicles. In the micrograph, you can also see that the synapse (located at center) is closely surrounded by many other structures, including glial cells, other axons and dendritic processes, and other synapses.



Neurotransmission in four steps:

Information is transmitted across a chemical synapse in four basic steps. Each step requires a different chemical reaction:

1. During synthesis, either the transmitter is produced by the cell's DNA and imported into the axon terminal or its building blocks are imported and it is manufactured in the axon terminal.
2. During release, the transmitter is transported to the presynaptic membrane and released in response to an action potential.
3. During receptor action, the transmitter traverses the synaptic cleft and interacts with receptors on the target cell's membrane.
4. During inactivation, the transmitter either is drawn back into the presynaptic

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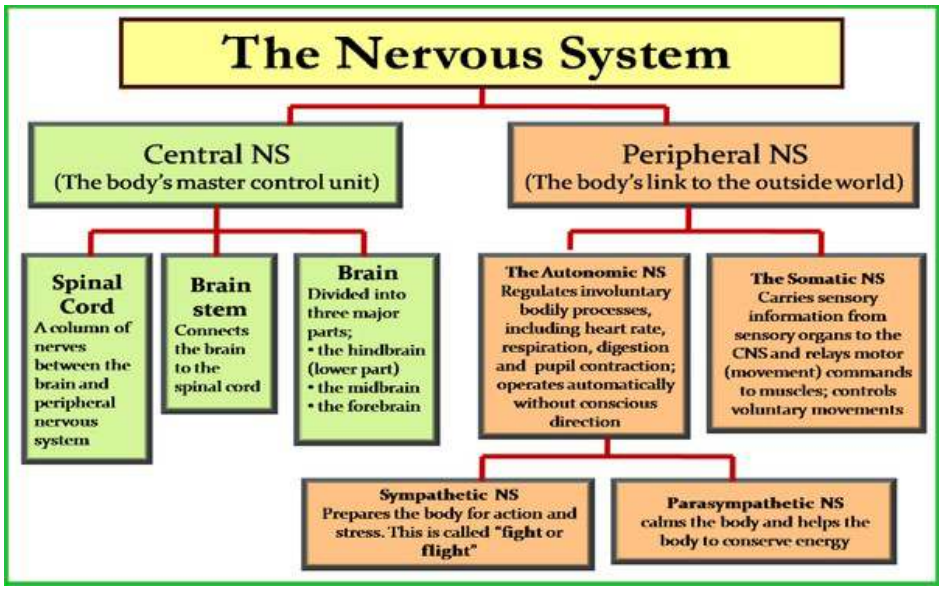
axon or breaks down in the synaptic cleft. Otherwise, it would continue to work indefinitely.

Brain development

- The human brain has a distinct architecture, as do the brains of each animal species.
- The features of individual brains also make each one distinctive.
- Neurons in the cortex are organized in layers and in clusters called nuclei that have specific functions in mediating behavior.
- When stained, layers and nuclei reveal distinctive shapes and colors that identify them.
- Within layers and nuclei, cells that are close together make the most of their connections with one another, but they also make long-distance connections, forming distinctive **fiber pathways or tracts.**
- Layers and nuclei can differ from one individual to the next and even in each of a single brain's two hemispheres.
- This anatomical individuation is likely related to the behavioral differences that individuals display.
- Neurons change their connections with one another.
- Brains lose and gain neurons and glia.
- The brain is also plastic: it can undergo enormous changes during a person's life span.

Functional Neuroanatomy

How does the Brain relate to the rest of the Nervous system?


The Nervous System
Central NS
(The body's master control unit)
Peripheral NS
(The body's link to the outside world)
Spinal Cord
A column of nerves between the brain and peripheral nervous system
Brain stem
Connects the brain to the spinal cord
Brain
Divided into three major parts;
• the hindbrain (lower part)
• the midbrain
• the forebrain
The Autonomic NS
Regulates involuntary bodily processes, including heart rate, respiration, digestion and pupil contraction; operates automatically without conscious direction
The Somatic NS
Carries sensory information from sensory organs to the CNS and relays motor (movement) commands to muscles; controls voluntary movements
Sympathetic NS
Prepares the body for action and stress. This is called "fight or flight"
Parasympathetic NS
calms the body and helps the body to conserve energy

- The brains and spinal cords of mammals are encased in protective bones.
- The skull protects the brain, and vertebrae protect the spinal cord.
- Together, the brain and spinal cord are called the **central nervous system, or CNS.**
- The CNS is connected to the rest of the body through **nerve fibers.**
- Some fibers carry information away from the CNS; others bring information into it.
- These nerve fibers constitute the **peripheral nervous system, or PNS.**
- One distinguishing feature between the central and peripheral nervous systems is that *PNS tissue will regrow after damage, whereas the CNS does not regenerate lost tissue.*
- The spinal and cranial nerves that bring information to the CNS are extensively connected to sensory receptors on the body's surface and to muscles, enabling the brain to sense the world and to react.
- This subdivision of the PNS is called the **somatic nervous system (SNS)**.
- Organized into sensory pathways, collections of fibers carry messages for specific senses, such as hearing, vision, and touch.
- Sensory pathways carry information collected on one side of the body mainly to the cortex in

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the opposite hemisphere.

- The brain uses this information to construct perceptions of the world, memories of past events, and expectations about the future.
- **Motor pathways** are groups of nerve fibers that connect the brain and spinal cord to the body's muscles through the SNS.
- Movements produced by motor pathways include the eye movements that you are using to read this document, the hand movements that you make while turning or scrolling through the pages, and your body's posture as you read.
- The parts of the cortex that produce movement mainly send information out via motor pathways to muscles on the opposite side of the body.
- Thus, one hemisphere uses muscles on the opposite side of the body to produce movement.
- Sensory and motor pathways also influence the muscles of your internal organs—the beating of your heart, contractions of your stomach, raising and lowering of your diaphragm to inflate and deflate your lungs.
- The pathways that control these organs are a subdivision of the PNS called the **autonomic nervous system (ANS)**.

- The nervous system, like the body, is symmetrical, with left and right sides.
- Structures that lie on the same side are **ipsilateral.**
- If they lie on opposite sides, they are **contralateral** to each other.
- If one lies in each hemisphere—which virtually all do—the structures are **bilateral**.
- Structures close to one another are **proximal**
- Those far from one another are **distal**.
- Any movement toward a brain structure is **afferent**, whereas movement away from it is **efferent**.
- Thus, the sensory pathways that carry messages from the body toward the brain and spinal cord are afferent; motor pathways leading to the body from the brain and spinal cord are efferent.

Protection and Support

The brain and spinal cord are supported and protected from injury and infection in four ways.

1. The brain is enclosed in a thick bone, the skull, and the spinal cord is encased in a series of interlocking bony vertebrae.
2. Within the bony case is a triple-layered set of membranes, the meninges.
3. The brain and spinal cord are cushioned from shock and sudden pressure changes by the cerebrospinal fluid (CSF)
4. The blood–brain barrier protects the brain and spinal cord by limiting the movement of chemicals from the rest of the body into the CNS and by protecting it from toxic substances and infection.

Meninges

- **Protective sheath -** Three membranous layers that surround the brain and spinal cord
- They function to protect the central nervous system, support blood vessels and enclose a cavity filled with CSF.

The three membranous layers are:

Dura Mater

- The outer dura mater is a tough double layer of tissue enclosing the brain in a kind of loose sack.
- Thick, tough, flexible, but stretchable

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Arachnoid Membrane

- The middle arachnoid membrane (from the Greek, meaning “resembling a spider’s web”) is a very thin sheet of delicate tissue that follows the brain’s contours.
- Soft and spongy, web-like

Pia mater

- The inner pia mater (from the Latin, meaning “soft mother”) is a moderately tough tissue that clings to the brain’s surface.
- Surface blood vessels of the brain

Cerebrospinal Fluid

- The brain’s basic plan is that of a tube filled with salty fluid called cerebrospinal fluid (CSF), which **cushions** the brain and **assists in removing metabolic waste**.
- It is produced in hollow interconnected chambers called ventricles
- It circulates through the brain’s four ventricles, the spinal column, and within the subarachnoid space in the brain’s meninges.
- Clear, Colorless liquid.
- Consists of Protein and Glucose.
- Approximately 125 ml.
- Brain: Weighs around 1400 gm
- Cannot handle its own weight.
- Floats in CSF: Reduces the weight to 80 gm.
- CSF is continually being made and drained off into the circulatory system through connecting channels among the ventricles.
- If the outflow in these channels is blocked, as occurs in a congenital condition called **hydrocephalus** (literally, “water brain”),
- Severe intellectual impairments and even death can result from the built-up CSF pressure.

Spinal Cord

- Part of the CNS within the spinal column.
- Communicates with all the sense organs and muscles except those of the head.
- 40 to 50 cm long and 1 cm to 1.5 cm in diameter.
- 31 segments defined by 31 pairs of nerves exiting the cord.
- Uniformly organized & divided into four regions:
  - Cervical (C)(8)
  - Thoracic (T) (12)
  - Lumbar (L)(5)
  - Sacral (S) (5)
  - 1 coccygeal nerve

The Brain

- Brain is an Old English word for the tissue found within the skull (cranium).
- Just as your body is symmetrical, having two arms and two legs, so is your brain. Its two almost symmetrical halves are called hemispheres.
- The **corpus callosum** connects the left and right hemispheres of the brain.
- The brain’s most conspicuous outer feature is the crinkled tissue that has expanded from the front of the tube to such an extent that it folds over and covers much of the rest of the brain.
- This outer layer is the cerebral cortex (usually referred to as just the cortex).

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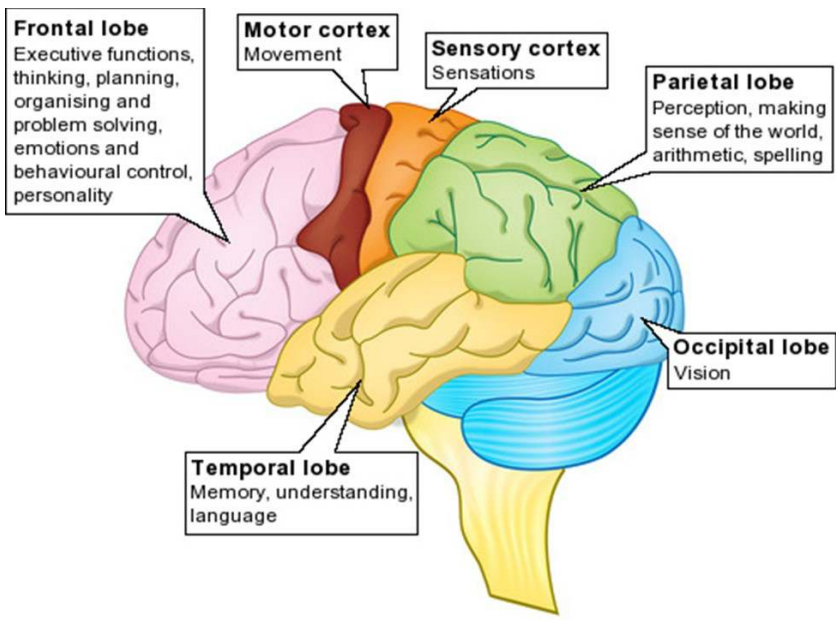
- The word cortex, meaning “bark” in Latin, is apt, because the cortex’s folded appearance resembles the bark of a tree and because, as bark covers a tree, cortical tissue covers most of the rest of the brain.
- The folds, or bumps, in the cortex are called **gyri** and the creases between them are called **sulci**
- Some large sulci are called **fissures**
- The **longitudinal fissure** divides the two hemispheres, and the lateral fissure divides each hemisphere into halves.
- Pathways called **commissures**, the largest of which is the **corpus callosum**, connect the brain’s hemispheres.
- The cortex of each hemisphere forms **four lobes**, each named after the skull bones beneath which they lie.



- The **temporal lobe** is located below the lateral fissure at approximately the same place as the thumb on your raised fist.
- Lying immediately above the temporal lobe is the **frontal lobe**, so called because it is located at the front of the brain beneath the frontal bones.
- The **parietal lobe** is located behind the frontal lobe
- The **occipital lobe** constitutes the area at the back of each hemisphere.
    - Frontal lobe
    - Parietal lobe
    - Occipital lobe
    - Temporal lobe
        - ***Lesions in the lateral surface of the temporal lobe can result in deficits in selective attention to visual or auditory input.***
        - That is, there is an inability to attend deliberately to one source or type of stimulation while filtering out others, or there is a generally reduced awareness of some particular form of stimulus.
    - Motor cortex
    - Sensory cortex

- The cerebral cortex constitutes most of the forebrain, so named because it develops from the front part of the neural tube that makes up an embryo’s primitive brain.
- The remaining “tube” underlying the cortex is the brainstem.

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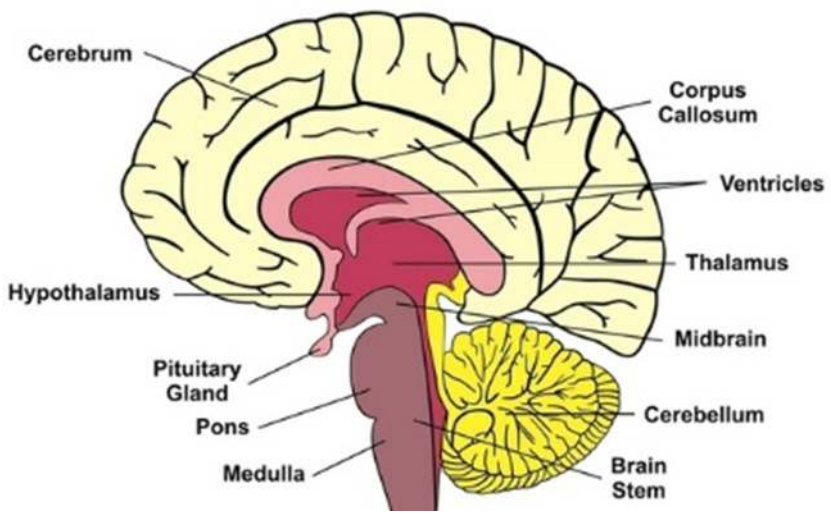
- The brainstem is in turn connected to the spinal cord, which descends down the back within the vertebral column.
- To visualize the relations among these parts of the brain, again imagine your upraised fist: the folded fingers represent the cortex, the heel of the hand represents the brainstem, and the arm represents the spinal cord.

The Brain stem/ Parts of the Brain



- The brainstem begins where the spinal cord enters the skull and extends upward into the lower areas of the forebrain.
- It consists of the **diencephalon, the midbrain, and the hindbrain**.
- A distinctive part of the brain stem comprises the many cranial-nerve nuclei that converge at its core and send their axons to the head muscles.
- The brainstem core consists of those cranial nerve nuclei and other nuclei that mediate a variety of regulatory functions.
- Additionally, bundles of sensory nerve fibers from the spinal cord pass through posterior regions of the brainstem on their way to the forebrain, and motor fibers from the forebrain pass through anterior regions of the brainstem on their way to the spinal cord.

The Hindbrain

- The most distinctive hindbrain structure is the **cerebellum**.
- It protrudes above the brainstem core, and its surface is gathered into narrow folds, or folia, like the gyri and sulci of the cortex, but smaller.
- At the base of the cerebellum are several nuclei that send connections to other parts of the brain.
- It contains about four times more neurons than the cerebral cortex, but they are much more densely packed, rendering its size much smaller.
- The cerebellum plays a role in **motor coordination** and motor learning and may participate in coordinating other mental processes.
- Damage to it results in equilibrium problems, postural defects, and impairments of skilled motor activity.
- The parts that receive most of their impulses from the vestibular system (sensory receptors for balance and movement located in the middle ear) help maintain bodily equilibrium.
- Within the hindbrain’s core mixture of nuclei and fibers lies a network, the **reticular formation**.

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- In 1949, Giuseppe Moruzzi and Horace Magoun stimulated this area electrically in anesthetized cats.
- The stimulation produced a waking pattern of electrical activity in the cats' cortices.
- The investigators concluded that the reticular formation's function is to control sleeping and waking—that is, to maintain "general arousal," or "consciousness."
- As a result, the reticular formation came to be known as the *reticular activating system*.
- *Damage to this area can result in permanent unconsciousness.*
- Nuclei within the upper **(pons)** and the lower **(medulla)** brainstem contain substructures that control vital body movements.
- Nuclei within the pons bridge inputs from the cerebellum to the rest of the brain.
- At the tip of the spinal cord, the medulla's nuclei regulate such vital functions as breathing and the functioning of the cardiovascular system.
- Damage to this brain region stops breathing and heart function and so can result in death.

The MidBrain

The midbrain has two main subdivisions: a posterior sensory component, the **tectum** ("roof"), the roof of the third ventricle, and, located anteriorly, a motor structure, the **tegmentum**, the "floor" of the third ventricle.

- The tectum receives a massive amount of sensory information from the eyes and ears.
- Its two sets of bilaterally symmetrical nuclei, the superior colliculi ("upper hills"), receive projections from the retina of the eye.
- The inferior colliculi ("lower hills") receive projections from the ear.
- Behaviors mediated by the colliculi include locating objects in surrounding space and orienting to those objects, be they visual or auditory.

Diencephalon

At the junction of the midbrain and forebrain, the diencephalon includes three thalamic structures:

- **Hypothalamus** ("lower room")
  - A small area near the base of the brain just below the thalamus.
  - Has widespread connections with the rest of the forebrain and the midbrain.
  - The hypothalamus connects to and interacts with the pituitary gland to control many endocrine functions.
  - Damage to any hypothalamic nucleus leads to abnormalities in motivated behaviours, such as feeding, drinking, temperature regulation, sexual behavior, fighting, or activity level.
- **Epithalamus** ("upper room")
  - The epithalamus is a collection of nuclei at the posterior of the diencephalon.
  - Pituitary gland is located on the ventral side of the vertebrate brain, while pineal gland is towards the dorsal side.
  - Pituitary gland secretes a number of hormones controlling various organs of the body but pineal gland secretes only one hormone.
  - The pineal gland - secretes the hormone melatonin, which influences daily

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and seasonal body rhythms.
    - Melatonin release during the dark portion of the day–night cycle contributes to the feeling of tiredness associated with our motivation to sleep.
- **Thalamus** (“inner room” or “chamber”)
    - The largest structure in the diencephalon, the thalamus, is composed of 20 nuclei, each projecting to a specific area of the cerebral cortex.
    - Almost all the information the cortex receives is first relayed through the thalamus.
    - It serves as a “hub,” interconnecting many brain regions.
    - Sensory information: Goes to the thalamus, which processes it and sends output to the cerebral cortex.

- Another structure, the habenula, regulates hunger and thirst.
- Functionally, the forebrain mediates cognitive functions
- The brainstem mediates regulatory functions such as eating, drinking, and moving
- The spinal cord conveys sensory information into the brain and sends commands from the brain to the muscles to move.

Gray, White and Reticular matter

- When a human brain is opened to reveal its internal structures, some parts appear gray, some white, and some mottled.
- These visually contrasting parts are described as gray matter, white matter, and reticular matter.
- **Gray matter** acquires its characteristic gray brown color from the capillaries and neuronal cell bodies that predominate there.
- Colloquially, the cortex is made up predominantly of layers of neurons, referred to as “our gray matter.”
- **White matter** consists largely of axons that extend from these cell bodies to form connections with neurons in other brain areas.
- The axons are myelinated (insulated) by oligodendrocytes and Schwann cells that are composed of the same fatty substance (lipid) that gives milk its white appearance.
- As a result, areas of the brain that consist of axon pathways appear white.
- **Reticular matter** contains a mixture of cell bodies and axons from which it acquires its mottled gray and white, or netlike, appearance.
- White and gray matter are sensitive to different stains.

The Limbic system

- Plays a role in self-regulatory behaviors including emotion, personal memories, spatial behavior, and social behavior.
- Among its principal structures, diagrammed in, are the **amygdala** (“almond”), nuclei in the base of the temporal lobe that participate in emotion.
- The **hippocampus** (“seahorse”), a structure lying in the anterior medial region of the temporal lobe that participates in personal memory (“what I did and when I did it”), and spatial navigation.
- The **cingulate** (“girdle”) cortex, a three-layered strip of limbic cortex that lies just above the corpus callosum along the medial walls of the cerebral hemispheres, is involved in sexual behavior, among other social interactions.
- The **hypothalamus** also plays a role in transmitting messages.For example, an idea (“It

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is dangerous to walk in the dark") from the neocortex could enter the circuit to be elaborated as a fear ("I feel frightened in the dark") and ultimately influence the hypothalamus to release hormones that activate a fight-or-flight arousal response

Neuropsychology of developmental abnormalities

Hypoxia

- The supply of oxygen to the brain is reduced significantly during the time of birth causing brain damage in the infant.
- It is also called birth asphyxia and leads to permanent cognitive damage such as cerebral palsy, learning disabilities, seizure disorders and developmental delays.

Anoxia

- Oxygen supply to the brain is completely cut off during childbirth due to prolonged labour which results in multiple cognitive deficits such as intellectual disability.
- This is observed in women with high risk pregnancies.

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Unit 3

Cognitive Neuropsychology

A field of study based on the concept that physical brain structure and functions specifically relate to psychological processes such as language perception, memory retention, recognition, and personality.

Attention

Defining attention

- Process of concentrating on specific features of the environment, or on certain thoughts or activities.
- Excluding other features of the environment.
- The concept of attention implies that we somehow focus a “mental spotlight” on certain sensory inputs, motor programs, memories, or internal representations.
- This spotlight might be unconscious, in that we are not aware of the process, or it might be conscious, as when we scan our memory for someone’s name.
- The development of language should increase the likelihood of conscious attention, but it is unlikely that all conscious processing is verbal.

Definition/ methods of studying attention

- **Selective or focused attention -** The mechanisms by which certain information is registered and other information is rejected, whether or not the latter enters conscious awareness.
- **Capacity or divided attention -** Some upper limit to the amount of processing that can be performed on incoming information at any one time.

Parts of the brain responsible for attention

Reticular activating system (RAS)

1. Regulates the level of cortical activation or arousal.
2. Sets a general cortical tone.
3. Plays a role in anticipatory responding. RAS may send a preparatory signal to the cortex to alert it to receive stimuli, and thus put it in a heightened state of readiness to receive.
4. Lesions to the RAS can result in lowered alertness or coma.

- Right fronto-parietal-thalamic neural network - Supports sustained attention

Thalamus

1. Receives activation from the reticular formation and projects this arousal to the cortex
2. Serves to select and relay information from subcortical regions to the cortex and, conversely, conveys cortical neural signals to subcortical regions.
3. Influences the selectivity of attention.

- Superior colliculus of the midbrain - plays a role in the reflexive movement of the eyes and head when orienting to visual stimuli.
- Inferior colliculus - is implicated when orientating to auditory stimuli.

Basal ganglia

1. Involved in shifting or switching sets, and thus is a component of the act of orienting to stimuli
2. Plays a supporting role in selective visual attention

- Cerebrum - coordinates focused attention, the ability to alternate and divide attentional processes, and the ability to sustain attention

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The brain and attention

- No single attention ‘centre’ in the brain
- Several regions are thought to form a distributed neural network that is collectively responsible for the attributes of attention
- Different cortical areas are activated in different attentional tasks.
    - Reticular Activating system (RAS)
    - Superior Colliculus - The superior colliculus (SC) is a structure in the midbrain that is part of the brain circuit for the transformation of sensory input into movement output. Its major function is orienting the animal, particularly with eye movements, to objects of interest in the outside world.
    - Pulvinar region of Thalamus - Recently it has been considered to be related more to the visual system, playing a role as the secondary visual system or extrageniculate visual system
    - Cingulate gyrus
    - Frontal Lobes
- Parietal cortex is activated for attention to location.
- The occipitotemporal cortex is activated for attention to features such as colour and form.
- The anterior cingulate and prefrontal areas show activation during both visual tasks. Thus, attention appears generally to require activation of both the anterior cingulate and some prefrontal areas in addition to activation of specific sensory areas related to a particular modality, such as vision or touch

Types of attention

Focused attention

The ability to respond discretely to specific visual, auditory or tactile stimuli.

Sustained attention (Vigilance)

The ability to maintain a consistent behavioral response during continuous and repetitive activity.

Selective attention

- The ability to maintain a behavioral or cognitive set in the face of distracting or competing stimuli. Therefore it incorporates the notion of "freedom from distractibility."
- Jeffrey Moran and Robert Desimone (1985) trained a monkey to hold a bar while it gazed at a fixation point on a screen.
- A sample stimulus (for instance, a vertical red bar) appeared briefly at one location in the receptive field, followed about 500 milliseconds later by two stimuli: one at the same location and another in a separate one.
- The key point: both targets were in the cell’s receptive field, but only one was in the correct location.
- When the test stimulus was identical with the sample and in the same location, the animal was rewarded if it released the bar immediately.
- In this way, the same visual stimulus could be presented to different regions of the neurons’ receptive fields, but the importance of the information varied with its location.
- As the animals performed the task, the researchers recorded cell firing in area
- A given cell might respond to one stimulus (for example, a horizontal green bar) but not to another (for example, a vertical red bar).

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- These stimuli were presented either in the correct location or in an incorrect location for predicting reward.
- The critical result is the behavior of the neuron in response to the effective target stimulus.
- When the effective stimulus was presented in the correct location, the cell was highly active.
- When the same stimulus was presented in an incorrect location, however, the cell was not responsive.
- When attention is focused on a place in the visual world, neurons appear to respond only to stimuli appropriate to that place.

Alternating attention

The ability of mental flexibility that allows individuals to shift their focus of attention and move between tasks having different cognitive requirements.

Divided attention

- This is the highest level of attention and it refers to the ability to respond simultaneously to multiple tasks or multiple task demands.
- Kahneman proposed that the capacity to perform mental activity is limited and must be allocated among concurrent activities.
- If a task is routine (such as driving on a road without much traffic), little attentional focus is used, and the driver can carry on a conversation. When the driver is turning across traffic at a busy intersection, However, attention must be focused on the task and the conversation briefly interrupted.
- In fact, in many jurisdictions, for a driver to use a phone in a moving vehicle is illegal because evidence clearly shows that attention is divided when we perform the two tasks concurrently.
- You may have noticed that when you attempt a difficult maneuver with a car, such as parking in a tight spot, you turn down your music.

Theories of attention

For more information refer : https://www.simplypsychology.org/attention-models.html

Broadbent's filter model of attention

- A filter prevents us from sensing all stimuli. This filter could be a personal factor such as interest or motivation. It could also be the nature of the stimuli.
- According to this theory there is a filter that prevents certain stimuli from being recognised or perceived.
- Here, the stimuli are not selected semantically but are processed for meaning once the selection has happened.

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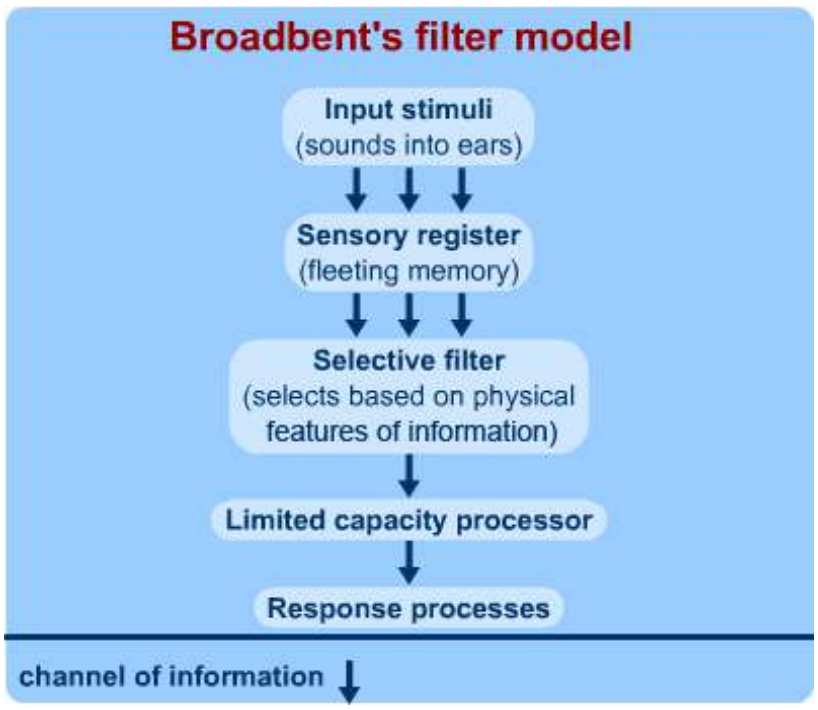

Cocktail party phenomenon

- The criticism is that of the cocktail party phenomenon- The cocktail party effect is the phenomenon of the brain's ability to focus one's auditory attention on a particular stimulus while filtering out a range of other stimuli, as when a partygoer can focus on a single conversation in a noisy room.

Treisman's Attenuation Model

- Out of all the stimuli, only a couple of them get detected as the intensity of the other stimuli is reduced.
- Once relevant stimuli is detected they are perceived.
- This theory states that other stimuli aren't completely blocked their intensity if just reduced or attenuated. They are not given enough importance.
- Instead of eliminating the other stimuli, this model suggests that they are simply attenuated.
- This process of attenuation of stimuli depends on whether these stimuli reach the threshold level of intensity.

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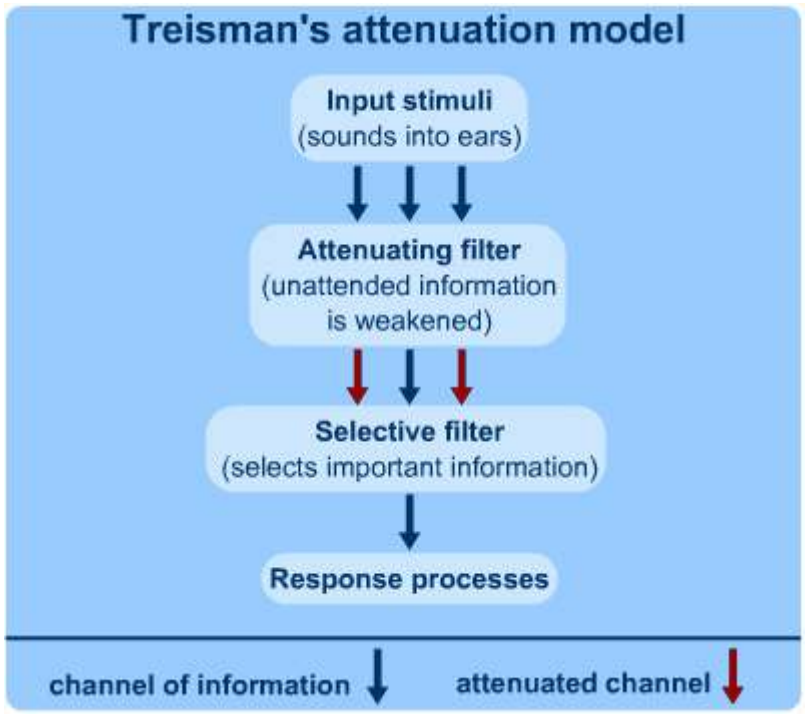
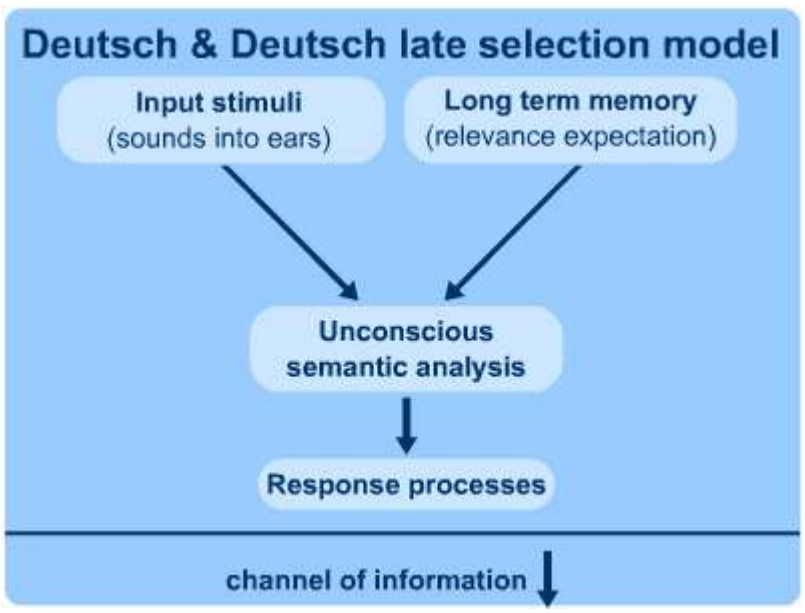


Deutsch and Norman's Late Selection Theory

- Detection and recognition happens before filtering happens.
- According to late-selection theory, within sensory limits, all stimuli—both attended and unattended—are processed to the same deep level of analysis until stimulus identification occurs; subsequently, only the most important stimuli are selected for further processing.
- Whether or not it gets selected depends on how relevant it is at that given time.



Models of attention

Mesulam 's Model of Spatial Attention (2000)

- Mesulam posits that a neural network involving the frontal, parietal, and cingulate cortices supports spatial attention to the external world.
- The parietal region generates an internal spatial representation (sensory map) of the extrapersonal environment,
- The cingulate cortex assigns and regulates motivational and emotional significance to

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extrapersonal elements

- The frontal cortex, particularly the frontal eye and surrounding areas, modulates and coordinates motor programs for exploration, scanning, foveating, fixating, and manipulating reaching) extrapersonal stimuli.
- The model thus conceptualizes spatial attention in terms of sensory representation, motivational importance and expectancy, and motor response.

Language

- It is a code to convert thoughts into output and input into thoughts.
- Intra and interpersonal communication.
- Bidirectional communication.
- Language is defined as a communication system that involves using words and systematic rules to organize those words to transmit information from one individual to another.
- From this definition we understand that there are two aspects of this system - 1) Symbols and 2) rules that organize these symbols.
- The foundation of systematic language is laid down by three sets of rules.
- The first rule is that the information must be symbols that carry meaning in the form of words and sentences.
- Second, this limited number of words can be combined to form infinite meaningful sentences.
- Lastly, these sentences must convey information independent of the settings they are used in.
- Language as a neuropsychological function is always closely linked to thinking and perception. This can be credited to the fact that our understanding of the world and responses to it is built on the basis of language

Dimensions of Language

1. Comprehension - reading, oral, inferential - Function of understanding things. Wernicke's area.
2. Production - expressing something, communication of feelings opinions - Broca's area
3. Repetition - not necessarily comprehending but the only repetition of statements made by someone else. Copying of someone _else's speech.
4. Reading - with or without comprehension. Primarily written or typed text that is used as input.
5. Writing - involves psychomotor communication to convey information
6. Copying - seen in earlier phases of schooling. Also has a visual component of seeing something and converting it into written language.

All of these dimensions have specific pathways and patterns of processing. For instance:-

Left ear > right auditory cortex > corpus callosum > left hemisphere > broca's and wernicke's area : ipsilateral

Right ear > Left auditory cortex > left hemisphere > broca's wernicke's area : contralateral

Brain Areas

1. Auditory cortex - the perception of speech.
2. Wernicke's area- comprehension of spoken speech
3. Broca's area- responsible for initiation/production of speech
4. Arcuate Fasciculus - the connection between Broca's and Wernicke's area

- Language is understood through visual stimuli as well as through the occipital lobe.
- This occurs through symbols.
- There is a pathway beginning from the retina traveling through the temporal lobe, superior colliculus,

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and then different parts of the occipital lobe depending on the action taking place on the input.

- It is an automatic process.

Roger Sperry's Split Brain experiment - https://embryo.asu.edu/pages/roger-sperrys-split-brain-experiments-1959-1968

Aphasias

Table 1. Differential Diagnosis of the Main Types of Aphasia.

Type of Aphasia	Speech	Comprehension	Capacity for Repetition	Other Signs	Region Affected
Broca's	Nonfluent; effortful	Intact or largely preserved	Impaired	Right hemiparesis (arm and leg); patient aware of defect and may be depressed	Left frontal (lower, posterior)
Wernicke's	Fluent; abundant; well articulated; melodic	Impaired	Impaired	No motor signs; patient may be anxious, agitated, euphoric, or paranoid	Left temporal (posterior and superior)
Conduction	Fluent with some articulatory defects	Intact or largely preserved	Impaired	Often none; patient may have cortical sensory loss or weakness in right arm; right-sided facial weakness may be seen	Left supramarginal gyrus or left auditory cortex and insula
Global	Scant; nonfluent	Impaired	Impaired	Right hemiplegia; may present without hemiplegia	With hemiplegia: massive left perisylvian lesion; without hemiplegia: separate frontal and temporoparietal damage
Transcortical					
Motor	Nonfluent; explosive	Intact or largely preserved	Intact or largely preserved	—	Anterior or superior to Broca's area; may involve part of Broca's area
Sensory	Fluent; scant	Impaired	Intact or largely preserved	—	Area surrounding Wernicke's area, posteriorly or inferiorly
Atypical					
"Basal ganglia"	Dysarthric, but often fluent	Impaired	May be intact or impaired	Right hemiparesis (arm and leg)	Head of caudate nucleus; anterior limb of capsule
"Thalamus"	Fluent; may be logorrheic	Impaired	Intact or largely preserved	Attentional and memory defects in acute phase	Anterolateral thalamus

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- It is a disorder of language that is neurogenic (caused by brain disease or injury), which involves the symbolic use of sound (that is language is the meaningful sense of the word).
- It is not due to deafness or motor paralysis, intellectual impairments, etc.
- If there is an insight into what is happening, it leads to a lot of frustration.
- It's not due to dysarthria or apraxia. These must be ruled out before diagnosing aphasia.
- Dysarthria often causes slurred or slow speech that can be difficult to understand. Common causes of dysarthria include nervous system disorders and conditions that cause facial paralysis or tongue or throat muscle weakness. Certain medications also can cause dysarthria.
- Apraxia is caused by brain disease or damage. The brain is unable to make and deliver correct movement instructions to the body.
- Aphasias involves damage to the brain areas responsible for language expression and understanding, as well as reading and writing.
- Aphasias frequently co-occur with speech disorders such as dysarthria and apraxia.
- There are different types of cortical aphasias depending on the type, lesion location, output, paraphasic errors, comprehension, repetition, and naming.

Wernicke's Aphasia

- Damage to the **temporal lobe** can result in Wernicke's aphasia, the most common type of **fluent aphasia**.
- A clinical picture of individuals with Wernicke's aphasia have no problem with speaking long complete sentences but these sentences often lack meaning and contain many unnecessary words.
- Example, they may say "You know that smoodle pinkered and that I want to get him round and take care of him like you want before." Although this sentence does sound complete and follows a proper syntax, it makes close to no sense.
- People with Wernicke's aphasia are often unaware of their spoken mistakes.
- Also called fluent aphasia and is located in the posterior superior temporal region.

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- The output is fluent although grammatically correct it is meaningless.
- There are paraphasic errors and comprehension is poor.
- Repetition and naming of objects are impaired.
- Even sign language is impaired.

Broca's Aphasia

- Also called **non-fluent aphasia**.
- Could be confused for word-finding dementia or tip of the tongue phenomenon.
- It is located in the posterior inferior frontal region.
- The output is nonfluent and agrammatic in nature.
- Although paraphasic errors are rare, comprehension is intact but repetition is impaired.
- The naming of items is marginally impaired. Show them a familiar object and ask them to name it but they may not be able to correctly identify it or convey it.
- They often have right-sided weakness or paralysis of the arm and leg because the **frontal lobe** is also important for motor movements.
- They do not have trouble understanding speech but rather have problems producing speech.
- They tend to omit small words such as "is", "and", and "the".
- They also limit their speech to short phrases for example they may say "walk dog" instead of "I will walk the dog".
- They are often aware of their speech mistakes which tends to make them frustrated.

Conduction Aphasia

- It is in the **parietal regions**.
- The speech output is fluent and grammatically correct.
- There are paraphasic errors although comprehension is good.
- Repetition and naming of objects are impaired.
- Individuals with conduction aphasia have difficulty repeating words and sentences even though they understand them and speak fluently.

Global Aphasia

- It is in the **frontal temporal-parietal regions** of the brain.
- There is very little output due to most language faculties being damaged.
- Comprehension is poor along with impaired repetition and naming of objects.
- Individuals with global aphasia may communicate through simple phrases repeatedly or use few words repeatedly but have trouble understanding the meanings of words and sentences due to limited comprehension abilities.

Transcortical Motor Aphasia

- The speech is nonfluent and agrammatic in nature.
- It is located in the **anterior border zone**.
- There are paraphasic errors along with poor comprehension.
- Although there is normal repetition, naming objects are impaired.

Transcortical Sensory Aphasia

- It is in the **posterior border zone**.
- There is fluent grammar but speech produced is meaningless.
- There are paraphasic errors and poor comprehension.
- Although there is normal repetition, naming objects are impaired.

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Transcortical Mixed Aphasia

- **Complete border zone**
- It is nonfluent with poor comprehension.
- Although there is normal repetition, naming objects are impaired.
- The paraphasic errors are variable and you may notice individual differences when it comes to these errors.

Anomic Aphasia

- It is in the **posterior inferior temporal region**.
- Speech output is fluent and grammatically correct.
- There are no paraphasic errors and comprehension is good.
- Repetition is normal though there is impairment in naming.
- Individuals with anomic aphasia have difficulty naming objects even though they know what the object is and what it may be used for.

Memory

- Memory is the process in which information is **encoded, stored** and **retrieved**.
- Any traumatic injury to the brain can lead to memory impairment depending on the site and intensity of the injury, from a neuropsychological perspective.
- Dementia, Amnesia and excessive alcohol use leads to memory loss.
- In degenerative instances, memory loss is gradual such as in the case of Alcohol abuse.
- In certain cases the onset is acute or sudden such as an accident that leads to brain damage.
- In the case of dementia, it is the neuropsychologists duty of delaying the onset or procrastinating the onset of severe dementia. As it is a chronic and insidious condition, it is a degenerative condition, it would take time to develop. There is MCI (mild cognitive impairment) in these individuals where they start showing early signs of dementia through a cluster of symptoms such as subtle everyday lapses in memory but not significant enough to cause damage to the individual's functioning. If we are able to identify this and intervene at that point, rehabilitation at this stage can delay the onset of severe dementia.
- London taxi driver's study showed a structural change in their hippocampus which was comparatively larger to accommodate the complicated multitudes of London city streets. This implied that when we consolidate new memories or learn something, there are structural changes that follow in the brain. A counter-argument to the findings of this study was to identify whether it was the size of the hippocampus that helped them become better drivers or the other way around. This was targeted at the correlational nature of the study. *The full study* - https://www.pnas.org/content/97/8/4398
- Memory can also be falsified. It can be manipulated by certain external factors- The EyeWitness Testimony. In a court proceeding, leading questions asked by a prosecutor manipulated the memory of the witness. *Fully Study* - https://nobaproject.com/modules/eyewitness-testimony-and-memory-biases

Defining Memory

Memory can be understood as a structure such as its location, part of the brain responsible for it and the function of this structure. Neuropsychologists focus on the *processes of memory* and its impairment and how that affects the individual's functioning.

- Some occupations require specific aspects of memory more than others. For example in the London taxi drivers study, spatial memory was researched.
- This process of memory included **Encoding, Storage, and Retrieval.** Damage to any of these functions can lead to deterioration and **Forgetting.**
- The way we encode information can vary. We could **chunk items together**. It is easier to remember

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words that stand out and there is a **Serial Position Effect** which is the effortless recall of words due to their position on the list either as the initial few and/or last few words. The fourth hypothesis of recall is the manipulation of memory due to the **error of commission.** When we recall words that are related to each other we tend to add other words to the list.

- Cognitive reserve is your brain's ability to improvise and find alternate ways of getting a job done.

The Serial Position Effects

- Discovered by Herman Ebbinghaus. The ability to recall the first few or last few items on the list better than the rest. The former is due to the primacy effect and the latter is due to the recency effect.
- He also came up with the nonsense syllables which are three-letter words with a consonant in the beginning and the end with a vowel in the middle. He used them to ensure absolute neutrality. Sometimes words are associated with experiences or subjective meanings attached which could influence the recall of the word.

Types of Memory

1. Declarative memory (explicit)

- Any kind of general knowledge related information.
- Personal Facts and sequence events.
- It is episodic and autobiographical in nature.
- It is easy to encode and recall when required.
- It is a memory of facts and events and refers to those memories that can be consciously recalled.

a. Episodic memory

- Represents our memory of experiences and specific events in time in a serial form from which we can reconstruct the actual events that took place at any given point in our lives.
- These are memories of events.
- They are autobiographical information.

b. Semantic Memory

- This is a more structured record of facts, meanings, concepts, and knowledge about the external world that we have acquired.
- It refers to the general factual knowledge, shared with others and independent of personal experience and of the spatial/temporal context in which it was acquired.

2. Non-Declarative memory (implicit)

- The amount of time and effort taken in encoding is more.
- Explaining this kind of information can be difficult.
- Includes skills or habits that are a part of procedural memory.
- Non-associative learning could be habituated through repeated exposure.
- Classical conditioning is also implicit.
- In marketing, advertisements tend to influence your behavior by creating implicit associations between something desirable and the brand.
- **Priming** is also a part of this memory where you can prompt someone to respond in a desired manner without their knowledge.
- It is the unconscious memory of skills and how to do things, particularly the use of objects or movements of the body such as riding a bike or playing guitar.

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3. Flashbulb memory

- It is emotionally loaded and a unique kind of memory.
- Consolidated by the mammillary body.
- The encoding that occurs under the influence of such extreme emotions is called flashbulb memories.
- A study conducted to test flashbulb memory uses a very strong emotional moment where even the minute events or details of the events are encoded. A common question of the research is related to 9/11. A highly detailed, exceptionally vivid snapshot of a moment or circumstances in which surprising and consequential or emotionally arousing news was heard.

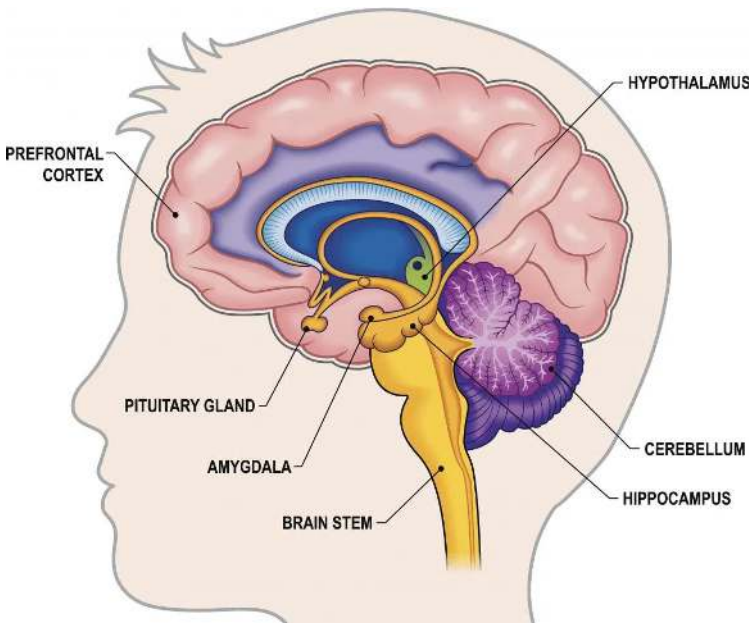
Atkinson and Shiffrin model of memory

They believed that there are **three kinds of memories**. Also called the Modal memory model.
https://courses.lumenlearning.com/atd-bhcc-intropsych/chapter/how-memory-functions/

1. **Sensory memory**
    a. Iconic memory - visual stimuli of something you see for a very brief time period before it gets registered in the short term memory.
    b. Echoic memory - auditory stimuli such as repeating a number as told to you
2. **Short term memory**
    If we pay attention to the sensory memory stimuli it gets encoded in short term memory
3. **Long term memory**
    Rehearsal of items in short term memory can move it to long term memory. Comprehension also plays a pivotal role. Rehearsal can also be behavioral in nature.

Neuropsychology of Memory

https://courses.lumenlearning.com/wsu-sandbox/chapter/parts-of-the-brain-involved-with-memory/



Hippocampus

- The hippocampus plays an important role in **storing memory**. Research has shown impaired declarative memory, the ability to state memory in words, does not remain intact in patients with hippocampal lesions.
- Case study of HM who has drug-resistant epilepsy. They removed the hippocampus which led to an absence of seizures but also impairment in anterograde memory.

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- It is also important in storing spatial memories. London taxi driver study.
- In severe dementia, there is a symptom of wandering behavior where they may step out of their homes and wander aimlessly and find it difficult to go back home. This is also due to impairment in spatial memory, although in dementia it is not merely due to memory it can be attributed to the disorientation of space and time.
- It is also responsible for the consolidation of memory. Impairment in the hippocampus can lead to impairment in learning new factual details, especially declarative memory. It also becomes difficult to comprehend and consolidate the learned items into a whole.

Amygdala

- This is a structure of the limbic system that contributes to **emotional memory**. Nostalgia, an emotion related to memory and past events are due to the amygdala.
- These emotions may not be extremely strong such as flashbulb memories.
- In the case of PTSD, the amygdala consolidates the memories of events that have been traumatic to the individual.
- It strengthens emotionally significant memory stored in other structures as well.
- **Emotion-provoking events** are remembered better than neutral events.

Prefrontal Cortex

- **Episodic memory or temporal sequence of events** is accounted for by the prefrontal cortex.
- It also helps in detecting lies as well where the individual is asked to reverse the sequence of events which would be difficult to do if they initially lied.
- Remembering things in sequence is regulated by the prefrontal cortex.
- It also holds things in your memory and manipulates it - working memory

Cerebellum and Striatum

- The cerebellum is responsible for **skilled activities** such as dancing, cycling, riding. The memory for these coordinated skills is also facilitated by the cerebellum.
- It is thought to participate in the storage of memories of learned sensorimotor skills.
- The **striatum** is a subcortical structure that plays a role in **habituated memory**.
- It is also responsible for memories that develop incrementally over many trials.

Assessments of Memory

AVLT or Rey's Auditory Verbal Learning Test

- As the name suggests it assesses verbal learning and memory.
- **Left temporal lobe** is attributed to verbal memory.
- Initially made for english speaking population but has been adapted into Chinese, Spanish, Hebrew, German, Flemish, and Dutch.
- Can be administered to individuals from ages 6-89 years.
- It measures immediate **memory span, new-learning, susceptibility to interference and recognition memory**.
- The original test was a one-trial word-list memory test and is one of the oldest mental tests in continuous use, although it has gone through revisions.
- The latest and most commonly used one consists of 15 nouns (List A) that are read aloud with a 1 second interval between words for five consecutive trials, each trial followed by a free-recall test.
- The order of presentation of words remains fixed across trials.
- Instructions are repeated before each trial to minimize forgetting.

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- After the fifth trial an interference list of 15 words (List B) is presented, followed by a free-recall.
- Immediately after this, a delayed recall of the first list is tested (Trial 6) without further presentation of those words is conducted.
- After a 20-min delay period, the examinee is again required to recall words from List A (Trial 7).
- Finally, a story that uses all the words from List A is presented, either orally or in written form (depending on the patient's reading ability), and the person must identify words recognized from List A.
- Alternatively, recognition can be tested with the use of a matrix array, in which the individual must identify List A words from a list of 50 words containing all items from Lists A and B and 20 words that are phonemically or semantically similar to those in Lists A and B.
- The list format is the more popular format, and there are good normative data for this version

Rey-Osterrieth Complex Figure Test

- It is a neuropsychological assessment in which examinees are asked to reproduce a complicated line drawing, first by copying it freehand (recognition), and then drawing from memory (recall).
- It is not a timed test. Every part of the figure is assigned a score and the max score is 36.
- The participants are not told about the trials and they are taken by surprise in the later recalls.
- *If the person's score falls below the 15th percentile is an indication of impairment.*
- It assesses visual-spatial constructional ability and visual memory.
- Can be administered to individuals aged 6-93 years.
- It assesses a variety of cognitive abilities such as planning, organizational skills, and problem-solving strategies, as well as perceptual, motor, and episodic memory.
- It consists of a copy trial followed by a recall trial 3 minutes later.
- Some administors give both immediate and delayed-recall trials but measure only delayed recall.
- The amount of delay can vary from 3 to 45 minutes. The length of delay chosen does not affect overall recall performance provided the delay is not beyond an hour.
- Most forgetting tends to occur in the first few minutes after copying.

Emotions

- There is a lack of consensus as to what emotions are and what part of the limbic system are involved in the processing of emotions.
- Not all expressions of unpleasant emotions are unpleasant or need intervention. For instance in the case of brain injury, emotional display such as anger or crying gives us a channel to explore their insight.
- But these insights can predispose the individual to develop anxiety and depression.

Defining Emotions

- A conscious, subjective feeling about a stimulus independent of where or what it is.
- We can infer emotions in others form their behaviour and by measuring the physiological changes associated with emotional processes.
- Affect vs Mood -
  - Affect is the here and now. It is cross sectional in nature. ' how are you feeling now?'
  - Mood is a predominant emotion across widespread temporal range. It's a more prevalent emotional experience and is longitudinal. 'how have you been feeling?'
- **Range** - The range of emotion refers to the variety of emotions. In mood disorders an individual may

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experience a restricted range of emotions.

- **Reactivity** - This refers to the magnitude of response. It is a dichotomous category which shows if they are reacting to a stimulus or are they showing blunt emotions.
- **Appropriateness** - does the emotion match the social context
- **Lability** - Frequent Fluctuation in mood. The oscillation between emotions in a very short period of time.
- **Subjective Mood** - How are you feeling? How have you been feeling answers to these questions are subjective moods.
- **Objective Mood** - our impression of the client's mood.
- If there are no significant impairments in mood then the client is **euthymic.**
- Emotion dysregulation is observed in individuals with mood disorders and brain injuries.
- They could have high sensitivity where emotional experience and expression is high.
- They could have high reactivity when the magnitude of their emotional experience is extremely high.
- They also take a long time to return to baseline levels.

Basic Emotions

- Paul Ekman worked on identifying universality of emotions where he spoke of how certain emotions are universal although their experience may be subjective and individualistic.
- He identified - Anger, Fear, Disgust, Sadness, Happiness, and Surprise. Contempt was also proposed along with these.

Functions of Emotions

- These emotions from an evolutionary perspective were key to our survival from external threats as well as bonding.
- *Fear* alerts us to escape from danger. If this did not occur we would be passive in our reaction to threats that would impact our survivals. The flight or fight instincts are also enhanced when we feel fear.
- *Anger* directs us to attack an intruder.
- *Disgust* tells us to avoid something that might cause illness. They also help us in identifying things that may deceive us by their appearance but may be bad for us such as stale food.
- These emotions guide our decision making and have adaptive values such as the experience of positive emotions in the company of someone would increase bonding with them.
- Although this limbic system is extremely old and our experience of fear is the same, the perception of fear has evolved therefore causing anxiety disorders or phobia.

Brain Areas Associated with Emotions

The Papez Circuit (1937) conceptualized that the limbic system is responsible for emotions.

The Cingulate Gyrus

- It is the curved structure covering the corpus callosum.
- It is responsible for autonomic functions such as regulating heart rate and blood pressure as well as cognitive, attentional, and emotional processing.
- There are cognitive processes that influence perception - cognitive distortions; how we cognitively process information including biases and hallucinations. All of these are influenced by the cingulate gyrus.
- Processing situation in a biased or negative manner.
- It also influences where and how we deploy our attention while processing information.
- Sometimes the nature of the stimuli is really high; it may directly go to emotional processing and skip cognitive processing.

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Parahippocampal gyrus

- It is the grey matter cortical region of the brain surrounding the hippocampus.
- It is responsible for **spatial memory**.
- Memories of spaces that you are very well acquainted with are stored here.
- In PTSD, the trauma associated with a very familiar space is also stored here which may trigger fear.
- Even popular tourist destinations, or an old hang out spot and the feelings associated with it is stored here.
- A classic study is conducted on rats where they are placed in a maze and observe how many trials they take to figure their way out.

Hippocampus

- It is related to **long term memory** and integrates emotional experience with cognition.
- Repeated exposure to trauma structurally changes the hippocampus. Even the volume is changed in the hippocampus in intense emotional conditions.
- Studies on war veterans to study the effect of emotional experience on the hippocampus.
- It is reversible through CBT (Cognitive Behavioural Therapy), minute but long lasting.

Amygdala

- Responsible for Anxiety, aggression, and fear conditioning.
- It is also responsible for **emotional memory and social cognition**.
- It processes the first emotional experience we have when we come across stimuli.
- It also consolidates learning.

Hypothalamus

- It regulates the autonomic nervous system via hormone production; indirectly controlling hormonal rates.
- It also regulates blood pressure, heart rate, hunger, thirst, sexual arousal, and circadian rhythm.
- It is also responsible for the sleep/wake cycle.
- It activates the sympathetic nervous system.
- These functions make the role of hypothalamus important as we cognitively experience an emotion and the bodily changes regulated by hypothalamus helps us interpret the emotion we are experiencing.

Mamillary Body

It consolidates emotional memory, especially **flashbulb memories**.

Nucleus Accumbens

This is responsible for reward functioning. The dopamine and serotonin pathways involved in processing rewards and influencing actions in anticipation are influenced by the nucleus accumbens.

Amygdala Hijack

- Under extreme contexts we lose control of our emotions.
- The limbic system becomes so actively involved in processing the threatening situation that it may even control our behaviour.
- An emotion provoking stimuli first reaches the thalamus from there it is segregated to different cortices according to the sensory information received.
- The thalamus is connected to the frontal lobe as well as amygdala. So if we perceive an extremely anger inducing situation this information is conveyed to the **frontal lobe** that will

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rationalize the emotional reaction and stop us from doing something aggressive. But in an amygdala hijack, this delegating network is compromised and the network between the thalamus and amygdala becomes stronger and we engage in behaviour solely regulated by emotions.

Consciousness

- This is a necessary function as without it we cannot pay attention, we cannot learn or consolidate memories.
- Consciousness is an **individual's state of awareness** of their environment, thoughts, feelings, or sensations; in order to experience consciousness, one must be both awake and aware.
- https://courses.lumenlearning.com/boundless-psychology/chapter/introduction-to-consciousness/

Brain Areas responsible for Consciousness

- There is a network of structures responsible for bringing about consciousness.
- The reticular formation was considered the seat of consciousness.
- Recent research revealed there are projections to the cortical regions from the reticular formation and networks in the subcortical regions or the thalamus.
- Any sensory input is received by the thalamus which later gets distributed to different parts of the brain.
- Moruzzi and Magoun (1949) found out the neurophysiological basis of arousal based on experiments on cats by electrical stimulations.
- Studying localization of function can be through either lesions or stimulations.
- The study found that natural arousal reaction from sensory stimuli led to the activation of the reticular formation and its prolongation in the hypothalamus and thalamus, resulting in the activation of the whole cerebral cortex.
- Neurons in the midbrain reticular activating system project throughout the cortex.
- When the organism is alert, these neurons fire at a high rate.
- The firing rate slows down when the organism is asleep.
- Activity within the reticular activating system helps maintain consciousness.
- The intralaminar nuclei of the thalamus interact with the reticular activating system to maintain awareness
- These nuclei are particularly vulnerable to oxygen deprivation. (Hypoxia and Anoxia)
- Oxygen supply is cut off to the brain or is partially cut off in situations such as heart attack, childbirth, high altitudes, and breathing problems. Irrespective of the source for this deprivation the nuclei are particularly sensitive and can lead to an altered state of consciousness.
- This can be potentially life threatening depending on the location and extent of damage.
- Any form of damage to the brain stem area can impact our consciousness leading to a vegetative state and coma.
- Altered state of consciousness is not always from a biological reason. The psychogenic nature of an altered state of consciousness can be due to dissociation.
- Psychogenic conditions of altered state of consciousness (dissociation in specific) - https://courses.lumenlearning.com/boundless-psychology/chapter/altered-states-of-consciousness/

Persistent Vegetative State

- Also called *unresponsive wakefulness*: a syndrome whose essential component 'is the absence of any adaptive response to the external environment, the absence of any evidence of a functioning mind which is either receiving or projecting information in a patient who has long periods of wakefulness' - Jennett and Plum 1972
- This adaptive response could range from reflex action to a flight or fight response.

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- Cognitive activities such as sensation, perception and attention are also absent.
- *The functioning mind is absent.* A functioning mind is part of the brain where there is electrical activity.
- These periods of wakefulness attested by the opening of eyes, whether spontaneous or elicited by sensory stimulation, differentiate the vegetative state from coma, in which the eyes remain permanently closed even under strong stimulations.

The locked in syndrome

- Also proposed by Plum and Posner in 1966
- Depending on the location of injury on the spinal cord, paralysis can be induced.
- Quadriplegia or tetraplegia - is paralysis caused by illness or injury that results in the partial or total loss of use of all four limbs and torso; paraplegia is similar but does not affect the arms
- The part of the spinal cord tested for these paralysis is the lumbar region which is the third region of the vertebral column, located in the lower back between the thoracic and sacral vertebral segments.
- In a locked in syndrome, the individual is unable to move although their sensory activities are intact. Only the muscles are paralysed.
- It is commonly associated with tetraplegia and inability to speak.
- There is voluntary movement of eyelids and vertical eye movements which is used for communication based on blinking or up and down ocular movements revealing the existence of a fully preserved conscious awareness and near-normal sensory and cognitive functions.
- There is numbness in tactile sensations.
- There is a vulnerability of diagnosis as there is a lack of communication and manifestations as both of them (vegetative state and locked in syndrome) are very similar which can lead to wrongful diagnosis.

Glasgow Coma Scale

- The Glasgow Coma Scale was first published in 1974 at the University of Glasgow by neurosurgery professors Graham Teasdale and Bryan Jennett.
- The Glasgow Coma Scale (GCS) is used to objectively describe the extent of impaired consciousness in all types of acute medical and trauma patients.
- The scale assesses patients according to three aspects of responsiveness: eye-opening, motor, and verbal responses.
- These functions can be grouped into hierarchical categories - Cortical functions which are the highest form of functions limited to a few species; Subcortical functions that of amygdala and hippocampus which we share with many other species; functions of the brain stem which are responsible for life sustaining functions.
- The Glasgow scale primarily looks at these functions although the focus is on the basic functions.
- The scale is administered when the patient is brought in a critical state almost immediately after a traumatic damage inflicted on the brain.

Scale and Scoring

- The Glasgow Coma Scale divides into three parameters: **best eye response (E), best verbal response (V) and best motor response (M).**
- It takes about 15 minutes to administer and is administered by a neuropsychologist and the interpretation of the scores can be used in planning of interventions.
- Some of these responses are observational in nature and some are consequences of stimulations.
- The levels of response in the components of the Glasgow Coma Scale are ‘scored’ from 1, for no response, up to normal values of 4 (Eye-opening response) 5 (Verbal response) and 6 (Motor response)
- The total Coma Score thus has values between three and 15, three being the worst and 15 being the highest.
- Anybody with a score of 8 or less is considered to be a comatose client which is often seen in the case of severe injury.
- A GCS score of 9 to 12 is seen in the case of a moderate head injury while GCS score of 13 to

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15 is called for a mild head injury.

- The score is the sum of the scores as well as the individual elements. For example, a score of 10 might be expressed as GCS10 = E3V4M3.

Eye Opening Response

- The highest score(4) awarded is for *spontaneously* where they are able to open their eyes without any stimulation.
- The next highest score (3) is awarded to any response to an auditory stimulus or to speech.
- The next level is awarded a score of 2 where pain is induced for a brief period of time to see if there is any eye opening response.
- When there is no eye opening response at all it is scored 1.

Best Verbal Response

- Here they check for orientation of time, place, and person. If they are able to respond to this they are awarded the highest score in the category(5).
- If they appear to be confused with their orientation they are awarded a score of 4.
- If they are able to communicate but they choose inappropriate words that are context irrelevant they are awarded a score of 3.
- If they are unable to express themselves in words but use incomprehensible sounds and words, either spontaneously or induced by a stimuli, they are given a score of 2.
- If there is no response at all, either spontaneously or induced by a stimuli they are given a score of 1.

Best Motor response

- Here they check whether the individual is able to obey commands and execute them then they are given the highest score of 6.
- If they move to a localised pain such as purposeful movements towards painful stimuli or move in response to pain in some part of the body they are given a score of 5.
- If there are neurological signs of flexion withdrawal (a spinal reflex intended to protect the body from damaging stimuli) from pain they are given a score of 4.
- If they display abnormal flexion or decorticate posturing accentuated by pain they are given a score of 3.
- In the presence of abnormal extension or decerebrated posturing they are given a score of 2.
- In the case of no response, either spontaneous or induced by stimuli they are given a score of 1.

Sleep

- Sleep is not a uniform state of being. Instead, sleep is composed of several different stages that can be differentiated from one another by the patterns of brain wave activity that occur during each stage. These changes in brain wave activity can be visualized using EEG and are distinguished from one another by both the frequency and amplitude of brain waves
- Sleep can be divided into two different general phases: **REM sleep** and **non-REM (NREM) sleep**. Rapid eye movement (REM) sleep is characterized by darting movements of the eyes under closed eyelids.
- Brain waves during REM sleep appear very similar to brain waves during wakefulness. In contrast, non-REM (NREM) sleep is subdivided into four stages distinguished from each other and from

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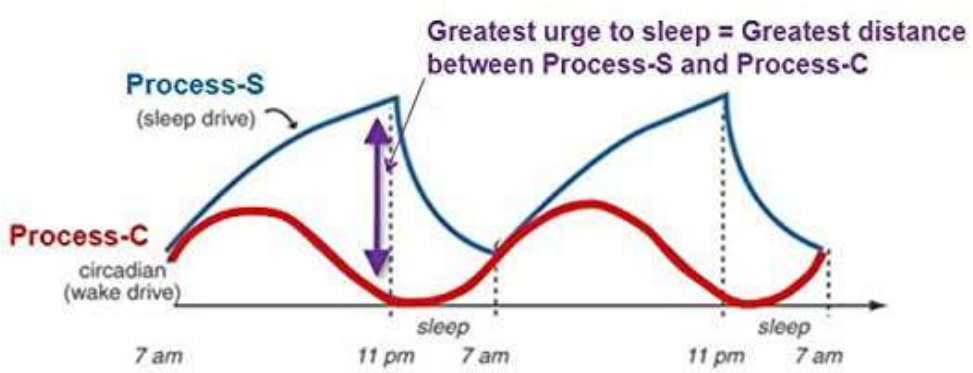
wakefulness by characteristic patterns of brain waves. The first four stages of sleep are NREM sleep, while the fifth and final stage of sleep is REM sleep.

- REM sleep is also called paradoxical sleep because of the active brain and rapid eye movement but lack of motor movements.

Brain Structures responsible for Sleep

- The *Suprachiasmatic Nucleus* is responsible for perception of cues that indicate time, also called zeitgebers, located in the hypothalamus.
- It also controls the circadian rhythm and generates neural and hormonal activities that help maintain a 24-hour cycle of bodily functions.
- Perception of these natural indicators of time leads to production of melatonin which is important for sleep.
- Melatonin pills are used to counter the temporal orientation disturbance created by jet lags.
- The Pineal Gland is also responsible for a healthy sleep cycle which interacts with the SCN to secrete melatonin.
- Another chemical responsible for sleep is adenosine.



- There are two simultaneous processes occurring called Process-S (sleep drive) and Process-C (wake drive)
- Process-C is responsible for maintaining wakefulness while Process-S ensures that we fall asleep.
- The Process-C or wakefulness increases from early morning, around 7 am due to certain environmental cues and then the wakefulness tapers down after 11pm and then repeats itself the next day.
- When we go against the circadian rhythm and stay awake, there is a build up of the adenosine chemical in the body.
- The period between 7am to 11pm sees an increase in Process-S or the sleep drive where the adenosine builds up and then drastically decreases once we fall asleep.

Sleep Deprivation

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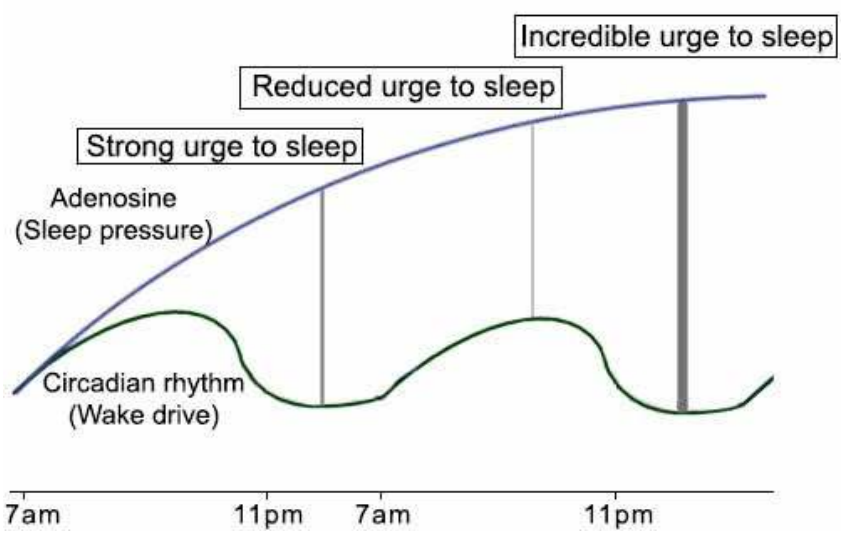

- When we pull all nighters or stay up beyond our usual bedtime, the adenosine chemical increases while the circadian rhythm continues to follow the same path.
- Therefore when we put off sleep, the chemical adenosine does not get an opportunity to lower its levels.
- There is a reserve of adenosine on the rise which in turn increases the magnitude of the sleep drive. This increase needs to be met with an adequate amount of sleep that coincides with the unawake periods, around 2 am, of the circadian rhythm. But when one tries to pull an all nighter, this sleep drive is not satiated.
- As the day progresses, mediated by the Process C, the urge to sleep may be relatively weaker around midday but the adenosine chemical continues to increase and subsequently so does the sleep drive.
- Finally, the magnitude of the sleep drive will be out of our control and it crosses the bodily threshold and here we experience an overpowering urge to sleep.
- Greater the sleep deprivation greater the volume of adenosine chemicals.
- This is an ideal situation where it is assumed that the extraneous variables such as lack of manipulation of environmental cues and hormones are not manipulated to change the circadian rhythm.
- Damage to any of the brain structures involved in sleep can also lead to sleep deprivation.
- A genetic condition associated with sleep deprivation is *Fatal familial insomnia* (FFI)
- It is characterized by an inability to sleep (insomnia) that may be initially mild, but progressively worsens, leading to significant physical and mental deterioration.

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Unit 4

Neuropsychology of basic psychiatric conditions

Diagnostic and Statistical Manual-V published by the American Psychiatric Association is the widely used manual to diagnose and treat Psychiatric disorders.

Schizophrenia

- It has always been easier to identify schizophrenic behavior than to define schizophrenia.

Portrait: (Just to understand Schizophrenia easily)

When Mrs. T. was 16 years old, she began to experience her first symptom of schizophrenia: a profound feeling that people were staring at her. These bouts of self-consciousness soon forced her to end her public piano performances. Her self-consciousness led to withdrawal, then to fearful delusions that others were speaking of her, and finally to suspicions that they were plotting to harm her. At first Mrs. T.'s illness was intermittent, and the return of her intelligence, warmth, and ambition between episodes allowed her to complete several years of college, to marry, and to rear three children. She had to enter a [psychiatric] hospital for the first time at 28, after the birth of her third child, when she began to hallucinate. Now, at 45, Mrs. T. is never entirely well. She has seen dinosaurs on the street and live animals in her refrigerator. While hallucinating, she speaks and writes in an incoherent, but almost poetic, way. At other times, she is more lucid, but even then her voices sometimes lead her to do dangerous things, such as driving very fast down the highway in the middle of the night, dressed only in a nightgown. . . . At other times and without any apparent stimulus, Mrs. T. has bizarre visual hallucinations. For example, she saw cherubs in the grocery store. These experiences leave her preoccupied, confused, and frightened, unable to perform such everyday tasks as cooking or playing the piano (Gershon and Rieder, 1992, p. 127)

- The **DSM-5 lists five symptoms** of schizophrenia, all displayed by Mrs. T. as described in the Portrait:
    1. **Delusions**, beliefs that distort reality. Mrs. T. harbored suspicions that people were plotting against her.
    2. **Hallucinations**, altered perceptions such as hearing voices—or for Mrs. T., seeing dinosaurs in the street—for which there are no appropriate external stimuli.
    3. **Disorganized speech**, such as incoherent statements or senseless rhyming. Mrs. T.'s speech and writing were incoherent yet had a poetic quality.
    4. **Disorganized or excessively agitated behavior,** exemplified by Mrs. T.'s dangerous late-night drives.
    5. Other symptoms that cause **social or occupational dysfunction**. Mrs. T.'s disturbing experiences left her unable to play the piano or even prepare a meal.
    - Not all patients will exhibit all symptoms; rather, the symptoms observed in different patients are heterogeneous, which suggests that their biological correlates also will be heterogeneous.
    - The symptoms come and go, much as in Mrs. T.'s case, but their severity is relatively constant after the first few years.
    - The DSM-5 specifies that at least two symptoms must be present for 6 months and include at least 1 month of active symptoms.
    - An alternative method of classifying schizophrenia's symptoms is to categorize them as type I or type II.
    - **Type I**, referred to as **positive symptoms**, is characterized by delusions, hallucinations, and/or disorganized or bizarre behavior.
    - **Type II** is characterized by **negative symptoms** such as flat affect, social withdrawal, and poverty of speech.

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Structural and functional impairment in Schizophrenia

- Most researchers agree that the brains of those with schizophrenia weigh less than healthy brains and that the ventricles are enlarged.
- Brains of those with schizophrenia have also been suggested to have smaller frontal lobes or at least a reduction in the number of neurons in the prefrontal cortex, as well as thinner parahippocampal gyri.
- Results of studies of cellular structure have shown abnormalities in both the prefrontal cortex and the hippocampus.

  Just for info: Investigators use neuroimaging to study brain activation in those with schizophrenia while they perform tasks such as the Wisconsin Card-Sorting Test. For example, the results of experiments by Daniel Weinberger and his colleagues (1992) show that controls exhibit significant prefrontal cortex activation when performing card-sorting. Patients with schizophrenia do not.

- Reduced gray matter volumes of the medial temporal, superior temporal, and prefrontal areas
- Episodic memory, processing of auditory information, and short-term memory/decision making, respectively, are critically dependent.
- Postmortem studies indicate that cortical gray matter reduction does not reflect loss of cell bodies but, rather, reduced dendritic complexity and synaptic density, which may impact inter-neuronal communication and integration

Prodrome of Schizophrenia

- A period defined by sub diagnostic symptoms and a decline in functioning
- There was significantly greater brain surface contraction away from the skull in the prefrontal area in individuals who later developed psychosis than in individuals who did not
- Sun, Stuart, Phillips, et al., 2009

Schizophrenia as a Neurodevelopmental Disorder

- Schizophrenia symptoms typically develop in late adolescence, and schizophrenia has long been seen as a neurodevelopmental disorder.
- David Lewis and Pat Levitt (2002) conclude that people who develop schizophrenia are much more likely to have experienced a combination of potentially adverse events in prenatal or perinatal life, including poor maternal nutrition, maternal infection, and obstetrical complications.
- Analyses of home movies of people who later developed schizophrenia have shown subtle but reliable disturbances in a variety of behaviors (motor, cognitive, social) many years before clinical symptoms of schizophrenia appear.
- In addition, there is evidence of a slow emergence of brain abnormalities, especially in the frontal lobe, during adolescence.
- The idea emerging is that schizophrenia reflects an epigenetic change related to a combination of genetic predisposition and environmental insults, which establish a developmental trajectory that eventually leads to the clinical syndrome.
- No single gene is implicated, and the extent to which early environmental insults might trigger changes in gene expression that contribute to any epigenetic basis for schizophrenia is unknown.

Cognitive symptoms of Schizophrenia

- Although the general tendency is to point to hallucinations and delusions (positive symptoms) and the poverty of affect and speech (negative symptoms) in schizophrenia, by far the most debilitating symptoms are cognitive.
- People with schizophrenia can have deficits in a diverse range of abilities, including working memory,

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episodic memory, language, executive function, attention, and sensory processing.

- The abnormalities in dopamine, GABA(It is the main inhibitory transmitter in the forebrain), and glutamate inputs to the prefrontal cortex lead to a disruption in the circuitry and activity in networks with significant prefrontal involvement.

❖ The unifying mechanism may be psychological (Figure 27.2, left), involving a core cognitive deficit, which Barch and Caesar label proactive control. Or the unifying mechanism may be neurobiological (Figure 27.2, right), in which biological abnormalities lead directly to cognitive abnormalities. This difference is important because the neurobiological view implies a need for direct pharmacological intervention, whereas the psychological view implies that cognitive therapies may be effective.

❖ Neurobiological interventions include antipsychotic medications, the mainstay of current treatments (Minzenberg and Carter, 2012). These drugs are effective in reducing positive symptoms, but even the newer atypical antipsychotics, with fewer motor side effects than the original neuroleptic drugs, have limited effects on deficits in cognitive functioning. Another neurobiological treatment uses either transcranial magnetic stimulation (TMS) or direct cortical stimulation to the scalp. The jury is still out on the usefulness of these treatments, especially for cognitive symptoms.

❖ Cognitive training procedures, however, show promise in remediating cognitive functions in schizophrenia. Cognitive behavioral therapy (CBT) employs problem-focused, action-oriented, structured treatments for eliminating dysfunctional thoughts and maladaptive behaviors (e.g., Morrison, 2009). This includes developing enhanced coping strategies for positive symptoms such as hallucinations or delusions as well as learning to schedule activities and to develop social skills training for negative symptoms such as lost motivation and social withdrawal. Another type of behavioral therapy flows from the experience

❖ Cognitive Dysfunction in Schizophrenia Two potential pathways may link deficits in DLPFC function, goal representation, and other cognitive impairments in schizophrenia (charted at top). (Left) In a proposed psychological mechanism, biological abnormalities impair a core deficit, proactive control. This faulty goal representation in turn leads to other cognitive deficits. (Right) In a proposed neurobiological mechanism, biological abnormalities directly influence multiple cognitive functions, including goal representation. (Information from Barch, D. M., and A. Caesar, Cognition in schizophrenia: Core psychological and neural mechanisms. A review by Michael Minzenberg and Cameron Carter (2012) concludes that cognitive training procedures show great promise for improving cognitive functions in people with schizophrenia.

Dementia (1:14:40 on the last video)

- Alzheimer's: Given below
- Lewy Body Dementia: Dementia due to abnormal microscopic deposits (Lewy Body) that damage brain cells over time.
- Vascular Dementia: Dementia caused due to impaired blood flow to the brain
- Fronto-temporal Dementia: Associated with personality changes
- Mixed Dementia

Structural changes in dementia:

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Table 1. Summary of characteristic FDG-PET findings in dementias (modified from Table 1 of Herholz, 2003).

Dementia	Brain regions with decreased glucose utilisation (reduced FDG uptake)
Alzheimer's disease	hippocampal formation and surrounding structures of the medial temporal lobe temporo-parietal association cortices posterior cingulate gyrus and precuneus frontolateral regions (at least partially)
dementia with Lewy bodies	primary and secondary visual cortex temporo-parietal association cortices posterior cingulate gyrus and precuneus prefrontal cortex
fronto-temporal dementia	predominantly medial frontal lobe, also frontolateral and temporal regions
semantic dementia	temporo-parietal regions prefrontal cortex
primary progressive aphasia	temporal lobe
subcortical ischemic vascular dementia	basal ganglia (nucleus caudatus), thalamus, variably also cerebellum, sensorimotor region, occipital lobe

Alzheimer's disease

- The most common type of dementia.
- It is characterized at first by anterograde amnesia and later by retrograde amnesia as well.
- Among the first areas of the brain to show histological change is the medial temporal cortex, but as the disease progresses, other cortical areas are affected.
- Here, too, the pattern of brain change and the pattern of memory deficit suggest that damage to the medial temporal cortex is related to anterograde amnesia and that damage to other temporal association and frontal cortical areas is related to retrograde amnesia.
- Alzheimer's-related amnesia is displayed mainly on tests of explicit memory, but eventually, implicit memory also may suffer.
- Towards the end stages of this disease, there is 'Brain Atrophy' and the brain 'shrinks' in volume. The hippocampus is much smaller in patients with Alzheimer's as well.

Parkinson's disease

- Degenerative, progressive disorder that affects nerve cells in deep parts of the brain called the basal ganglia and the substantia nigra.
- Substantia nigra- Dopamine, planning and controlling body movements
- Increased activity of cerebellum
- Postencephalitic Parkinson's demonstrated a unique pattern of brain damage in the form of death of cells in the substantia nigra. The cells of the substantia nigra are the point of origin of fibers that extend into the frontal cortex and basal ganglia and to the spinal cord. The neurotransmitter at the synapses of these projections is dopamine.
- Urine analysis of deceased individuals who had Parkinson's showed a 90% decrease in the dopamine levels of the brain.
- Dopamine depletion may not account for the whole problem in some people, however, because decreases in norepinephrine have been recorded, and numerous results show that cells in some basal ganglia nuclei may degenerate as well.

Huntington's disease

- A progressive brain disorder
- Defective gene on chromosome 4
- Motor, cognitive and psychological conditions
- Huntington's chorea- involuntary jerking or writhing movements.
- It is a hyperkynetic disorder focused on increased motor activity and hysteria.

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- Huntington’s disease results in intellectual deterioration and personality changes as well as abnormal movements called chorea.
- At autopsy, the brains of people with Huntington’s show cortical shrinkage and thinning.
- The basal ganglia are grossly atrophied and show marked neuronal loss. A dominant explanation of the disease is an imbalance among the various neurotransmitter systems of the basal ganglia.
- It is postulated that the intrinsic neurons of the basal ganglia die in the course of the disease leaving a largely intact nigrostriatal dopamine pathway.
- Decreased inhibition of dopamine cells by the GABA pathway results in increased dopamine release in the basal ganglia. The dopamine system hyperactivity is believed to produce the characteristic choreas, although exactly how is not clear

Creutzfeldt-Jakob disease

- Progressive neurodegenerative condition
- Cognitive, Motor and Psychological symptoms
- Abnormal versions of a kind of protein called a prion.
- Invariably fatal
- Spongy holes, visible under a microscope, that develop in affected brain tissue.

Anxiety disorders

- Sympathetic and Parasympathetic Nervous System
- Panic Disorder: Lower metabolism in the left inferior parietal lobe and overall decreased bilateral cerebral blood flow (CBF)
- Elevated glucose uptake in the amygdala, hippocampus, thalamus, midbrain, caudal pons, medulla, and cerebellum as measured by positron emission tomography (PET)
- A common factor among all anxiety disorders is fear or anticipated fear which is often associated with a neural network between the Anterior cingulate cortex, medial prefrontal cortex, Orbitofrontal cortex and hippocampus that control the fear response generated by the amygdala.
- The anterior insula is responsible for eliciting the somatic symptoms of fear.
- Structural MRIs have shown reduced hippocampal volume and thinning of the dorsolateral prefrontal cortex in patients with PTSD. This is associated with memory.
- There is also evidence that abnormalities in the HPA axis may characterize some anxiety disorders, with an increase in corticotropin-releasing factor (CRF) concentrations in blood.

Mood disorders

Bipolar disorders, Depression

- The main symptoms of **major**, or **clinical, depression** are prolonged feelings of worthlessness and guilt, disruption of normal eating habits, sleep disturbances, a general slowing of behavior, and frequent thoughts of suicide.
- **Mania**, by contrast, is a mental state of extreme excitement characterized by excessive euphoria.
- An affected person often formulates grandiose plans and behaves with uncontrollable hyperactivity.
- In **bipolar disorder**, periods of mania may switch, sometimes abruptly, into periods of depression and back again, or may alternate with periods of regular behavior.

Neurochemical Aspects of Depression

- The observation that patients given reserpine for high blood pressure often became severely depressed was a source of insight into the neurobiological basis of depression.
- Reserpine depletes monoamine neurotransmitters, including norepinephrine, dopamine, and serotonin, which led to the idea that monoamines might be reduced in depression. Postmortem studies of suicide

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victims supported this hypothesis.

- The **Monoamine theory of depression** states that depression was at least sometimes due to an absolute or relative depletion of either norepinephrine and/or serotonin at important receptor sites in the brain. This could be caused by impared synthesis of the neurotransmitters in the presynaptic neuron through increased degradation of the neurotransmitters once they were released into the synapse or through altered functioning of postsynaptic receptors. Although, there have been studies that have found exactly the opposite of what is hypothesized by this theory.
- Dopamine dysfunction, especially reduced dopaminergic activity, is suggested to play an important role in at least some forms of depression (atypical and bipolar) as it is predominantly involved in the experience of pleasure and rewards.
- An added complication is that no clear unifying theory accounts for the action of antidepressant medications to treat depression.
- Neurotrophic (that is, growth-supporting) factors may play a role in the action of antidepressants. Brain-derived neurotrophic factor (BDNF) is upregulated by antidepressant medication and downregulated by stress. Given that BDNF acts to enhance the growth and survival of neurons and synapses, BDNF dysfunction may adversely affect monoamine systems through the loss of either neurons or synapses.
- The possible role of stress in lowering BDNF production is important because, as has become increasingly clear, monoamines modulate hormone production and secretion via the hypothalamic–pituitary–adrenal circuit, or HPA axis
- Cortisol, a hormone secreted by the adrenal glands, is associated with stress reactions. The best-established abnormality is oversecretion of hydrocortisone (cortisol).
- Fluoxetine (Prozac) as a major drug for treating depression.

Brain areas and Depression

- The general symptoms of depression might lead us to predict a diffuse reduction in cerebral activity, which was the general finding in early PET studies.
- There has been a striking difference in the prefrontal cortex and associated structures in people with depression.
- Reduced grey matter or thickness of anterior cingulate cortex, posterior orbitofrontal cortex, nucleus accumbens and hippocampus have shown abnormalities in people with depression and similar mood disorders.
- In addition, imaging reveals a loss of glia (largely oligodendrocytes) and synapses in anterior cingulate cortex (ACC), DLPFC, and amygdala which results in altercations in the amygdala networks and the default prefrontal networks.
- Neuroimaging studies have shown that depression severity correlates with decreased blood flow and metabolism in ACC and ventromedial prefrontal cortex.
- PET studies also have shown an abnormal increase in glucose metabolism in the amygdala that correlates with the severity of depressive symptoms. The amygdala assigns emotional significance to stimuli
- Amygdala activity stimulates cortisol release, suggesting that this may increase HPA-axis activity in depression.
- The increased activity in the orbital cortex could correspond to an attempt to modulate or inhibit amygdala activity.
- The symptom of depression related to uneasiness and dread is hypothesized to have resulted from the overactivation of the somatic marker provided by visceral activation which is usually observed during nonconscious cognitive processes.
- In depression, the prefrontal–anterior cingulate abnormalities are thought to be responsible for the increased visceral experiences.
- The prefrontal cortex has extensive connections with a variety of subcortical regions involved in visceral experiences, including the amygdala, hypothalamus, periaqueductal gray, locus coeruleus, raphe, and brainstem autonomic regions.

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Unit 5

Neuropsychological assessment

The Practice of Neuropsychological Assessment

- **Neuropsychological assessment** is a performance-based method to **assess** cognitive functioning. This method is used to examine the cognitive consequences of brain damage, brain disease, and severe mental illness.
- By the 1990s, neuropsychologists had an impressive choice among tests. At one end of the spectrum are standardized test batteries with fixed criteria for organicity, atypical behavior assumed to have a biological (organic) basis. Thus, organicity criteria are used to distinguish behavioral symptoms from those not directly related to brain pathology.
- These tests have in common the advantage of straightforward administration, scoring, and interpretation. There is little need to understand the theoretical bases of the tests or the nuances of cerebral organization to administer them. Such understanding is necessary for interpretation, however.
- At the other end of the testing spectrum are individualized test batteries that require particular theoretical knowledge to administer and interpret. These assessments are more qualitative than quantitative. The testing of each patient is tailored both to that person's etiology and to the qualitative nature of his or her performance on each test.

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- Composite test batteries occupy a middle ground between the standardized and individualized batteries. Each test is administered in a formalized way and may have comparison norms, but qualitative performance and the pattern of test results are considered.
- Across this spectrum, each battery is constantly changing in response to test revisions and developments as well as to the clinical population being evaluated. One constraint on the choice of any test, however, is the clinical neuropsychologists' training. The use of tests based on theory requires an understanding of the theory of cerebral organization.
- The NIMHANS neuropsychological battery of tests (which are described in detail later) needs to be administered under supervision at least 20 times before you'll be qualified to administer it on your own.

Factors affecting the choice of test

- Damage to different cortical regions can produce discrete behavioral changes. Working backward from this knowledge to localize unknown brain damage seems reasonable. That is, given a particular behavioral change, we should be able to predict the site or sites of the disturbance most likely to be causing the change.
- Even after the practitioner has chosen tests appropriate for a specific etiology, significant questions must be resolved. First, how sensitive are the tests? If a large brain region is dysfunctional, the assessment test need not be particularly sensitive to demonstrate the dysfunction. If the lesion is small, on the other hand, the behavioral effect may be rather specific.
- A related problem is that various factors may interact with brain pathology to make interpreting test results difficult. Both age and ethnic or cultural background can influence test performance. Therefore, test scores with strict cutoff criteria cannot be interpreted.
- Unlike standard, quantitative psychometric assessment, neuropsychological assessment must be flexible. This flexibility makes interpretation difficult and requires extensive training in fundamental neuropsychology and neurology as well as in neuropsychological assessment.
- Finally, significant differences in test performance are related to factors such as sex and handedness. In addition, test performance is often biased by demographics. For example, in one three-city study of the effects of head trauma, investigators found that healthy participants in one city performed as poorly as brain-damaged subjects in another. Significant demographic differences influenced test performance and has to be considered in interpreting test results.

Goals of Neuropsychological Assessment

The goal of assessment in general clinical psychology is diagnosing a disorder for the purpose of changing behavior. Similarly, personality tests are used with an eye toward defining and curing a behavioral disorder, such as generalized anxiety.

Neuropsychological assessment:

- **Aims to determine a person's general level of cerebral functioning and to identify cerebral dysfunction and localize it where possible:** In doing so, the assessment attempts to provide an accurate and unbiased estimate of a person's cognitive capacity.
- **Facilitates patient care and rehabilitation:** Serial assessments can provide information about the rate of recovery and the potential for resuming a former lifestyle.
- **Identifies mild disturbances when other diagnostic studies have produced equivocal results:** Examples are the effects of head trauma or the early symptoms of a degenerative disease.
- I**dentifies unusual brain organization that may exist in left-handers or in people who have had a childhood brain injury:** This information is particularly valuable to surgeons, who would not want, for example, to remove primary speech zones inadvertently while performing surgery. Such information is likely to be obtained only from behavioral measures.
- **Corroborates an abnormal EEG in disorders such as focal epilepsy:** Indeed, the primary evidence may emerge from behavioral assessment, because radiological procedures, including noninvasive imaging, can fail to identify specifically the abnormal brain tissue giving rise to the seizures.
- **Documents recovery of function after brain injury:** Because some recovery may be expected, documentation aids not only in planning for rehabilitation but also in determining the effectiveness of medical treatment, particularly for neoplasms (tumors) or vascular abnormalities.
- **Promotes realistic outcomes:** Assisting a patient and the patient's family in understanding the patient's possible residual deficits facilitates setting realistic life goals and planning rehabilitation programs.

Basic Concepts

A COMPREHENSIVE NEUROPSYCHOLOGICAL EVALUATION EXAMINES:

1. Attention
2. Memory

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3. Ability to Learn
4. Intelligence Language and communication
5. Speed and efficiency
6. Motor abilities
7. Personality Emotional status

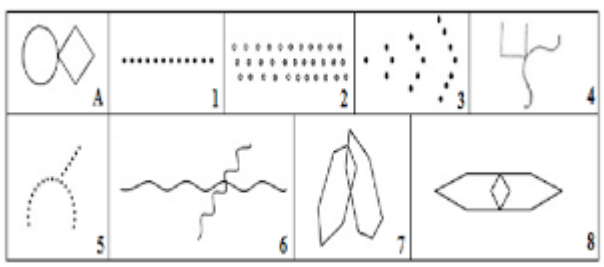
Higher-order and executive cognitive functions:

1. Anticipating
2. Initiating
3. Problem-solving
4. Abstract reasoning
5. Insight
6. Judgment
7. Drawing conclusions
8. Self-control
9. Managing time

Neuropsychological Tests

Bender Gestalt Test

Many cognitive impairments can be screened through this test.



Administration

1. The cards given above are shown one by one to the client in that order. They must draw it out
2. The client must be given ample sheets and pens or pencils. Do not change the orientation of the cards.

Interpretation

1. Many different aspects of these figures are considered for the assessment i.e size, orientation etc
2. It gives an idea of representation and visuo-spatial functioning (how they represent these images in their mind and how they put it on paper). Each card measures a different aspect which can be interpreted using the complex manual that comes with the test.
3. Primarily measures visuo-spatial coordination and associated motor skills but it can give you an insight into more things about the client.

NIMHANS Neuropsychological battery of tests

- It includes a battery of tests i.e has 19 tests to measure different things.

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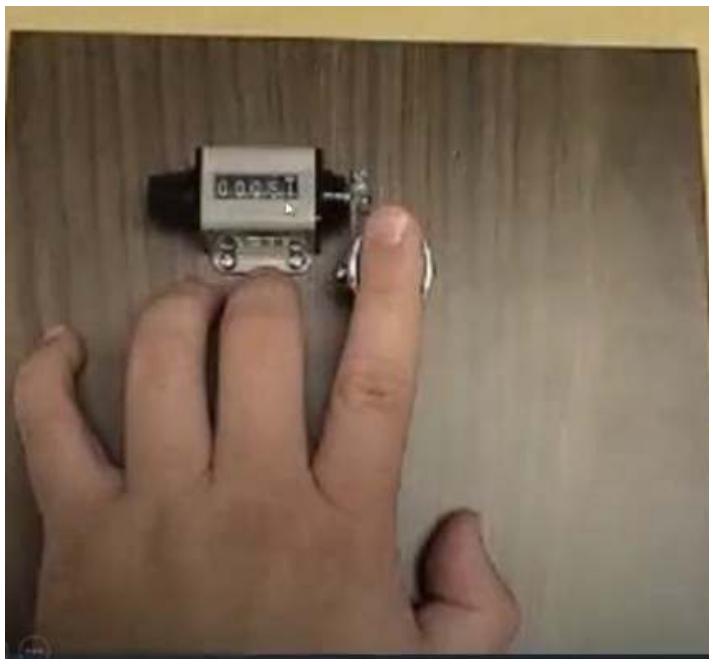
Domain	Function	Tests
Speed	Motor Speed	Finger Tapping Test
	Mental Speed	Digit Symbol Substitution Test
Attention	Focused Attention	Color Trails
	Sustained Attention	Digit Vigilance Test
	Divided Attention	Triads Test
Executive Functions	Verbal Fluency	Controlled Oral Word Association
	Category Fluency	Animal Names Test
	Design Fluency	Design Fluency Test
	Working Memory	N Back (Visual & Verbal)
	Set Shifting	Wisconsin Card Sorting Test
	Response Inhibition	Stroop
	Planning	Tower of London

Domain	Function	Test
Comprehension	Verbal Comprehension	Token Test
Learning & Memory	Verbal	Auditory Verbal Learning Test
	Visual	Complex Figure Test
Visuo-Spatial Construction		Complex Figure Test

- The test can be administered in any order but we must ensure every test is completed. No breaks can be given in between tests.
- You can split it into multiple sessions based on the client's requirements.

Finger tapping test: Motor function

- Apparatus created by NIMHANS
- The client cannot see the counter because that may influence their results
- The client is asked to tap the apparatus with the index fingers of both the dominant and non-dominant hand for 10 seconds each.
- Multiple trials are conducted and the average number of taps is taken and compared with the norms given in the manual. (5 trials for each hand)
- It is useful for checking the motor speed in clients who may have had injury or impairment in the motor cortex or the spine. (could be a variety of things but basically motor function)
- Instructions “Start tapping as fast as you can and stop when I say stop”. The client is not told about the 10s time limit



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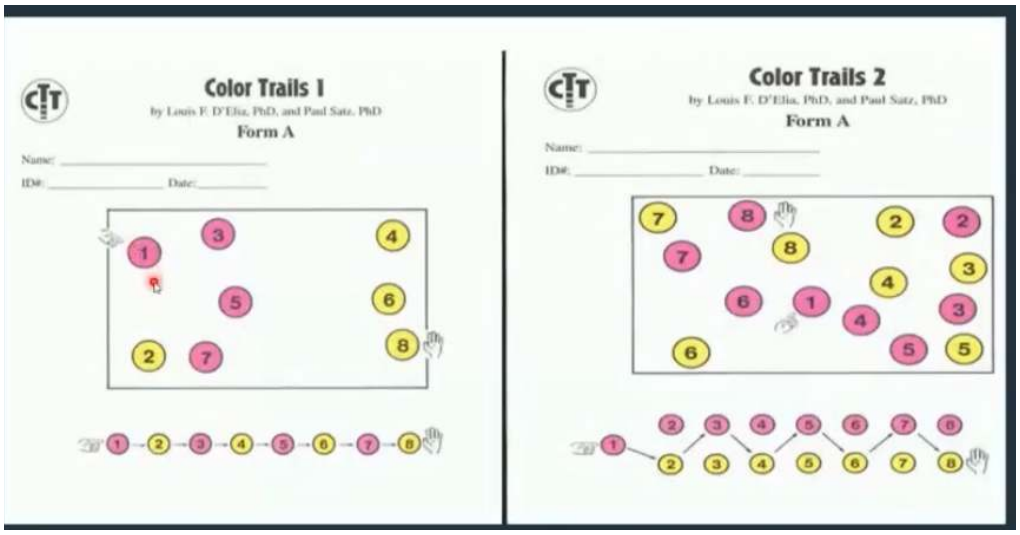
Digit Symbol Substitution Test: Mental Speed

- Each number is assigned a symbol (like seen in the top) and the client has to look at the numbers and write the corresponding symbol.
- Until the black line in the first row, it is a sample period where the therapist explains and helps the client. Once the client understands it completely, they have to do it on their own.
- A few things can be observed here. Time taken or the omission or commission of something extra are all things we can observe.
- The focus is on time taken and number of errors but other aspects can also be observed. If the client is having any difficulty properly managing their motor function or if there's an inversion (look for repetitive patterns)
- These other observations can be very helpful in your assessment

Color Trails Test: 1 and 2: Focused attention



- The hand symbols indicate the starting point and finishing point
- Colour Trails 1: Easier

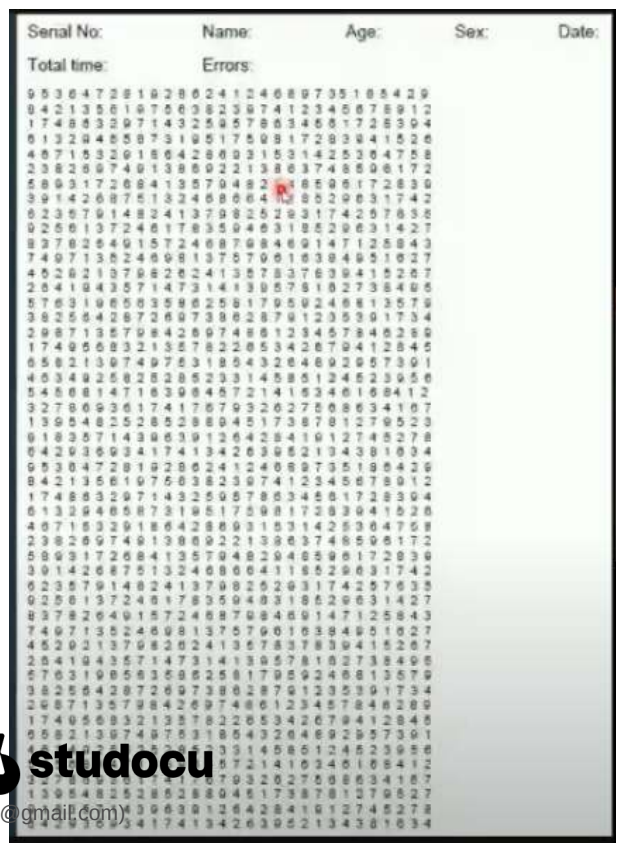
The client is ideally given a printed sheet where they must basically connect the dots in order of numbers i.e from 1 to 9. Time taken and errors should be noted.

- Colour Trails 2: Harder

The client is asked to connect the dots starting from a pink 1 but then the colors must be alternative. So pink 1, yellow 2, pink 3 and so on. The pink 2 or yellow 3 serve as distractions.

Digital Vigilance Test: Sustained attention

- Clients are asked to cancel out the 6 and 9 in this long list.



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- There is usually no time limit and we just wait for the client to finish. Usually takes about 10-15 minutes but if it takes longer, like the client takes double the time or even more, you can stop the test.
- There's a cut off point after which you can stop them which according to the manual is anything more than 15 minutes which puts them below the 15% mark and thus indicates impairment in sustained attention.
- You can stop after a point because after it takes that long, there might be no more information you can gather even if they take time.
- The errors (omissions and commissions) and time taken are calculated. Based on the age, sex and time taken, the manual puts a particular percentile which is them interpreted.
- You can also notice other information like does the client get frustrated? Are they trying with difficulty? etc.

Triads Test: Divided Attention

- The client is asked to do two tasks at the same time. For example, do an arithmetic sum on one side while the therapist traces a number on their palm. So that they have to focus on both tasks. Strict instructions about the use of dominant or non-dominant hands and the sums are given in the manual.
- A modification of this is when the first task involves giving three words and the client has to select the odd one out and the second task is writing a number on their hand. So the client has to focus on both things. (Like Potato, brinjal and pineapple: Which is the odd one out?)

Controlled Oral word fluency: Fluency

- Also called COWAT: Controlled Oral Word Association Test
- A single letter is given to the participant (among F, A and S). They are given one by one and the client has to come up with as many words as they can in one minute. Plurals and proper nouns are not allowed.
- We take the average of the number of correct words from these trials and it is converted into a percentile. The percentile is then compared to the norms in the manual

Animal Names Fluency: Fluency

- The client has to come up with as many names of animals as they can in a minute. There are 3 restrictions: No birds, no reptiles and no fishes
- Measures fluency in a particular category

Design Fluency: Fluency

- Certain symbols are given to the client. A horizontal line, semi circle, circle and a vertical line are given. They have to come up with as many new designs as possible using these symbols in 5 minutes
- The client has to use all these symbols to come up with as many designs as possible after which the number of correct designs are counted and converted into a raw score and then into a percentile.

Visual and Verbal N Back: Working memory

(N stands for a number like 0 back, 1 back, 2 back and so on in increasing order of difficulty)

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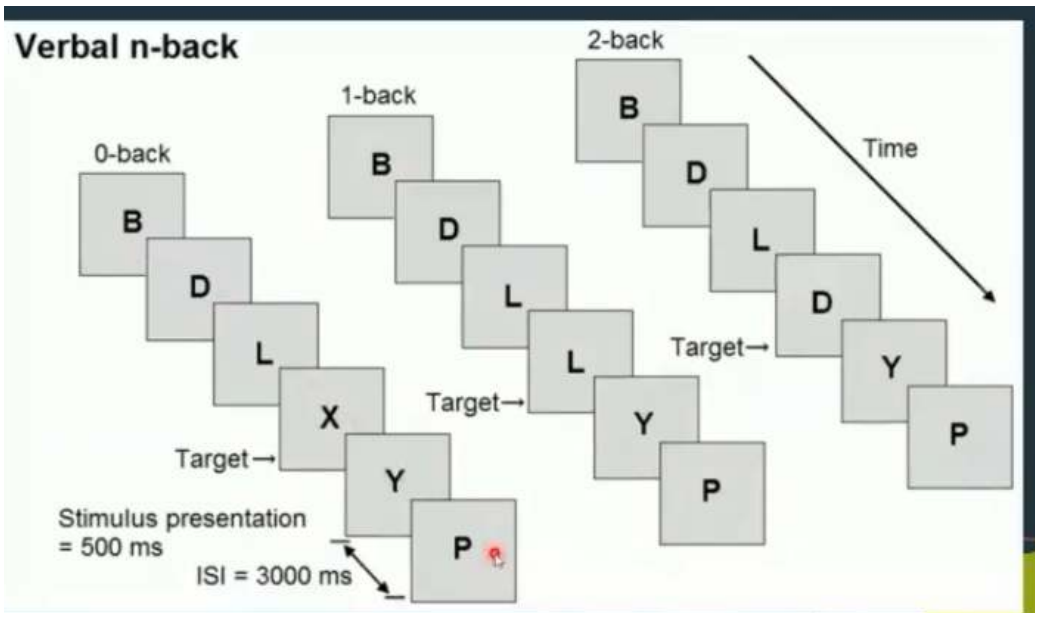

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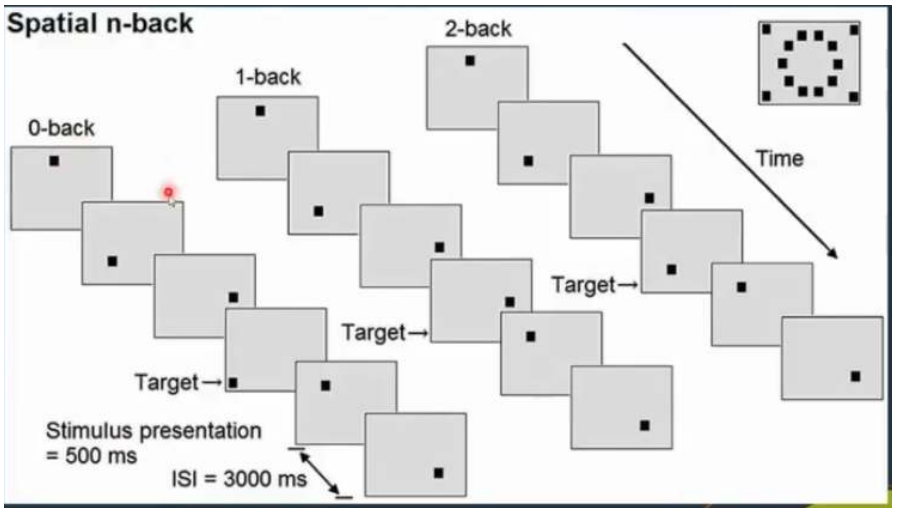
- These can be done with any stimulus (like emojis, or color) Typical batteries involve this method though



Visual

- In the 0 back condition: Each of these letters are shown one by one and the client has to indicate a particular target stimulus (In Nimhans test, it's by tapping the desk). Here the target is X, so they have to indicate they saw this when it is presented
- In the 1 back condition: Letters presented one by one, the client has to recognise when a letter is repeated. (In this case, the L)
- In the 2 back condition: The target is presented followed by a distractor, then the target again. So in the above case, the target is D which is followed by L and then another D. This is what the client has to indicate. (Basically a pattern of a letter, followed by something else, then the same letter)
- In the 3 back condition: There'll be 2 distractors between the target

Verbal

- The letter is pronounced out loud (So in Indian context, da la la basically syllables we use in indian languages). The same procedure as above, just that the syllable is said out loud

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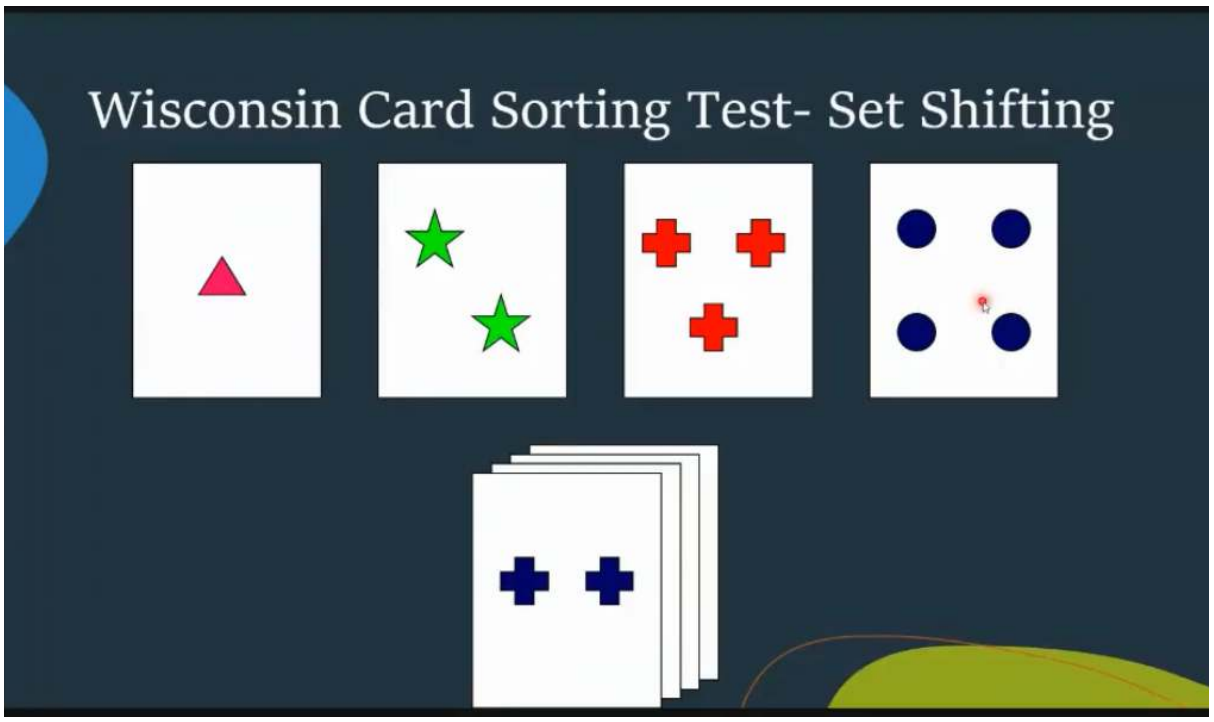
Wisconsin Card sorting Test: Set shifting (Starting from 1:34:40 in the 16th video)

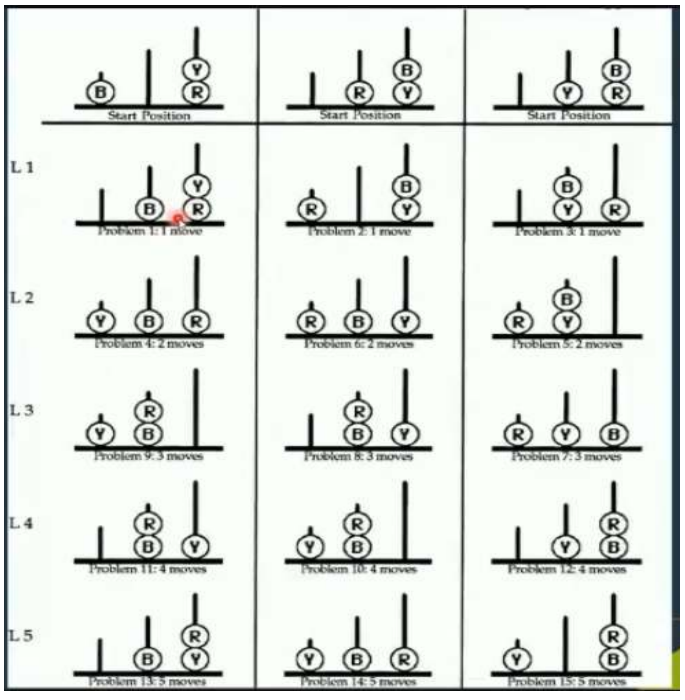


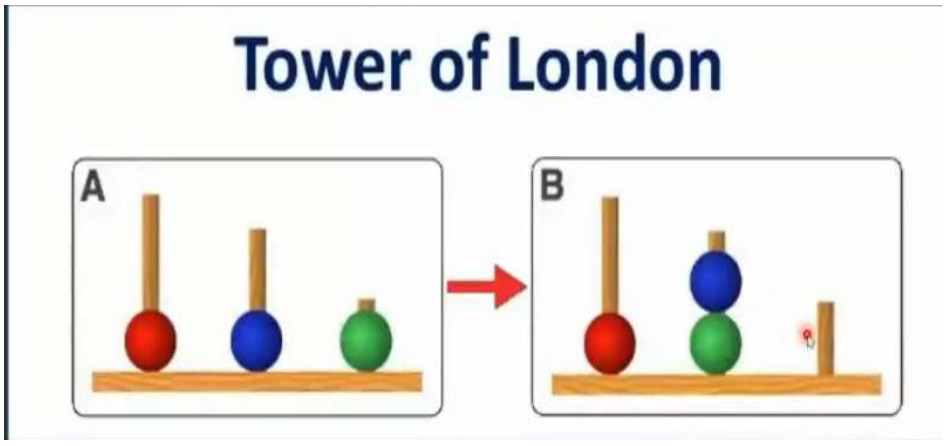
There are multiple ways to sort these cards: (NIMHANS asks you to do this in the sequence given below)

1. Based on color
2. Based on shape
3. Based on number of items

- The 4 cards on top are called key cards and are placed on top of the table.
- Instructions will be “I have a concept in my mind and I won’t tell you what it is but I just want you to place the 60 cards below on the stack you choose. After you place the card, I'll give you feedback as to whether it’s right or wrong. You have to guess what the concept is”
- It’ll be one of the 3 criterias you will have in mind.
- Every 10 correct answers, you change your concept. After some trial and error, the client will figure out what it is

Tower of London: Planning





- Commonly administered test, even as an independent test. (1:47:11 in the 16th video)
- There are 2 sets of this apparatus, one for the client and one for the therapist.
- The therapist changes the position of these balls and then the client must try and replicate it on

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their apparatus.

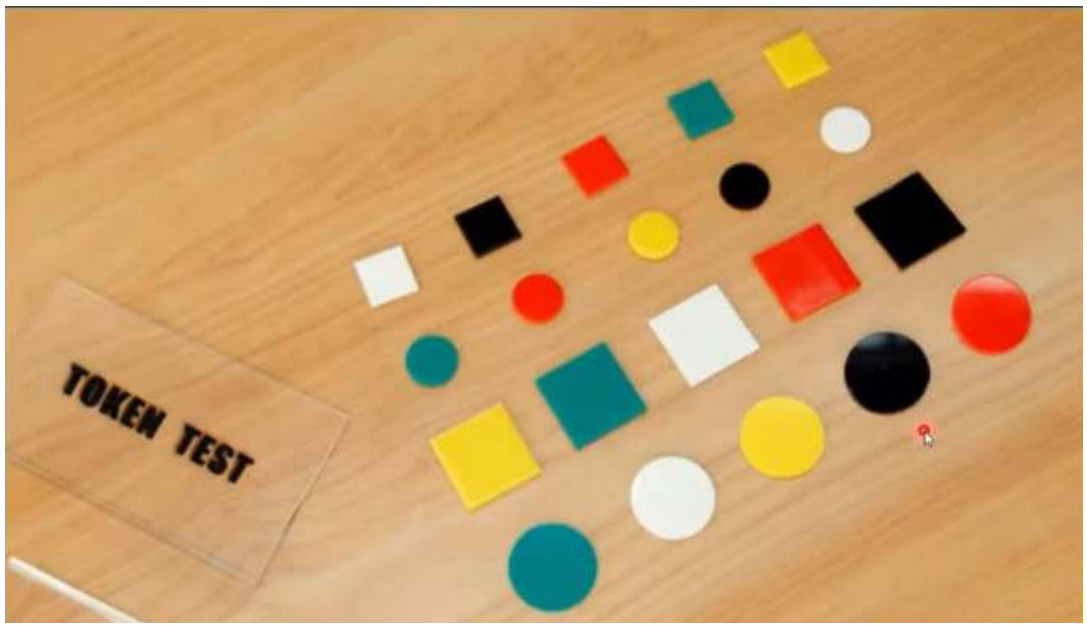
- There are 3 rules
    1. Based on the height of the stick, it can accommodate only a specific number of blocks. The longest can hold 3, the middle on has 2 and the last one can only hold one.
    2. You can only take one block at a time
    3. Once you take a block, you have to place it on one of the sticks. You can't put in on the table or hold it in your other hand.
- You have to create the pattern made by the therapist should be recreated keeping these rules in mind. (The example above is one of the easiest pattern shifting that is possible)
- Time taken and number of moves are noticed which is then converted into a percentile
- It involves multiple trials with the difficulty rising every time. The blocks are rearranged into the starting position every time a new pattern is given.
- Number indicated in the sheet is the minimum number of moves. The greater the number of moves taken, the lower their percentile will be indicating a problem with planning.

Stroop test: Response inhibition

Red Red Blue Green Red Red
Yellow Green Green Green Yellow Green
Blue Blue Yellow Yellow Blue Blue
Green Red Red Blue Green Red
Green Blue Green Yellow Green Green
Yellow Green Blue Blue Blue Yellow
Blue Yellow Red Green Red Blue

- There are two conditions
    1. CONGRUENT PHASE: The client has to read the word they see
    2. INCONGRUENT PHASE: The color needs to be given
- Congruent - incongruent = stroop effect which indicates your level of response inhibition

Token Test: Comprehension



- In the first phase a simple instruction is given "Take the small white square and place it on the small white circle"
- Initially only two or a few tokens are given. As the difficulty increases, so does the number and complexity of the instructions. (Meaning giving multiple instructions in one go)
- You can skip this test if you already have an indication of the client's comprehension

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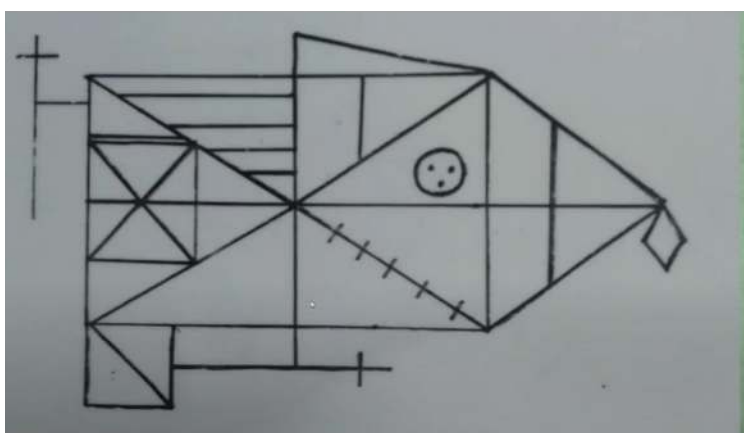
AVLT: Auditory Verbal Learning Test: Verbal Memory (Attributed to the left temporal lobe)

List 1	List 2	List 3	List 4	List 5	List 6	List 7	List 8
Drum	Desk	Doll	Dish	Violin	Orange	Book	Window
Curtain	Ranger	Mirror	Jester	Tree	Armchair	Flower	Barn
Bell	Bird	Nail	Hill	Scarf	Toad	Train	Hand
Coffee	Shoe	Sailor	Coat	Ham	Cork	Rug	Weather
School	Stove	Heart	Tool	Suitcase	Bus	Meadow	Home
Parent	Mountain	Desert	Forest	Cousin	Chin	Harp	Hot
Moon	Glasses	Face	Water	Earth	Beach	Salt	Balloon
Garden	Towel	Letter	Ladder	Knife	Soap	Finger	Mouse
Hat	Cloud	Bed	Girl	Stair	Hotel	Apple	Crayon
Farmer	Boat	Machine	Foot	Dog	Donkey	Chimney	Fountain
Nose	Lamb	Milk	Shield	Banana	Spider	Button	Rose
Turkey	Gun	Helmet	Pie	Radio	Bathroom	Log	Stranger
Color	Pencil	Music	Insect	Hunter	Casserole	Key	Stocking
House	Church	Horse	Ball	Bucket	Soldier	Rattle	Teacher
River	Fish	Road	Car	Field	Lock	Gold	Toffee

- A list of words are presented. Only one list is provided and then the client is asked to recall these words immediately. The words are then again presented and this goes on for 5 trials
- This is also done with delayed recall where we present the list, then wait 20 minutes before asking the client to remember them. This is the 6th trial
- Then there is recognition: This part is when the words presented early are presented with a bunch of new words (so approx 30 words) and the client has to tell us if the word we presented was in the first list of words.
- Any order is okay and they just have to say out loud the words they remember.
- This is converted into a percentile and can be compared with norms to find out how much impairment is caused, if any.

Complex Figure Test: Visual memory, Visual-spatial construction (Tests damage to the right temporal lobe)

- In the first phase, the client is asked to copy this figure
- Again, there'll be immediate recall and delayed recall.



- It also has the component of visuo-spatial abilities because the client has to copy this figure
- Phase 1: Copy the figure (doesn't measure memory but visuo-spatial abilities)
- Phase 2: Give the client a new piece of paper and take away the stimulus card to measure immediate recall
- Phase 3: After about 30 minutes, they are asked to recreate the picture again. Measures delayed recall
- The scoring can get quite complex because every single line, their orientation is to be scored.

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Neuropsychological Rehabilitation

Cognitive Reserve:

- Think about a bank. You save up money and invest carefully so that in the future, in case you run into any issues, you have some money to fall back on.
- In the same way, we can build up our cognitive reserve through certain activities. It is basically how active our brain is. Something like eating healthy, solving difficult puzzles and education helps you maintain a strong cognitive reserve
- It serves as a prophylactic measure. These things serve as a preventative measure to delay or insulate you from diseases such as dementia
- It helps in faster recovery from trauma. It might be a gradual recovery from a traumatic brain injury. Higher levels of cognitive reserves aids in this recovery.
- Maintain a healthy brain for higher cognitive reserves.
- This happens due to **neuroplasticity**.

Neuroplasticity:

- In the past, people thought that the brain was plastic enough (i.e could mould and be flexible in case of damage) that only happened until adolescence and then stopped. But we now know that neuroplasticity continues into adulthood.
- Depending on the site of damage, extent of damage and the cognitive reserve (i.e how healthy your brain is), neuroplasticity is possible.
- The brain is able to build new neural pathways and areas connected to the site of damage can take up the work done by the damaged part. It can be done through certain exercises (some of the rehabilitation measures we will discuss further)
- It's not as simple as it sounds because there are a lot of complications based on the injury, site etc. Especially in cases where there is a lot of damage to the areas of the brain.

2 protocols to understand the extent of damage:

- Structural imaging: In case there is any physical damage to the brain, if it's only functional damage, then it is considered normal.
- LOC: Complete loss of consciousness
- AOC: This includes things like feeling dizzy, dazed, confused etc but not loss of consciousness. Brief periods of fluctuations in their consciousness
- PTA: Can they recall what happened after the injury and if there's amnesia, how long is it?
- GCS: Has to be done within 24 hours.

Criteria	Mild	Moderate
Structural imaging	Normal	Normal or abnormal
Loss of consciousness (LOC)	0-30 minutes	>30 minutes and <24 hours
Alteration of consciousness/mental state (AOC)*	up to 24 hours	>24 hours, severity based on other criteria
Posttraumatic amnesia (PTA)	0-1 day	>1 and <7 days
Glasgow Coma Scale/Score (GCS) (best available score in first 24 hours)	13-15	9-12

*Alteration of mental status must be immediately related to the trauma to the head. Typical symptoms would be looking and feeling dazed and uncertain of what is happening, confusion, and difficulty thinking clearly or responding appropriately to mental status questions, and being unable to describe events immediately before or after the trauma event.

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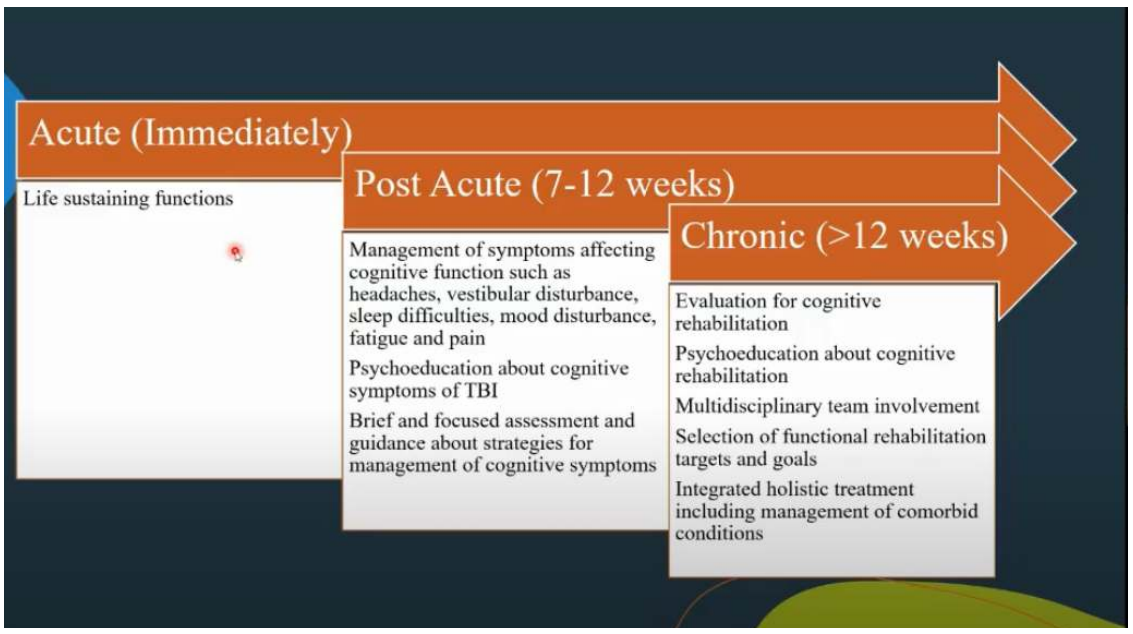
This is helpful in figuring out the further course and chart a Plan of Recovery.

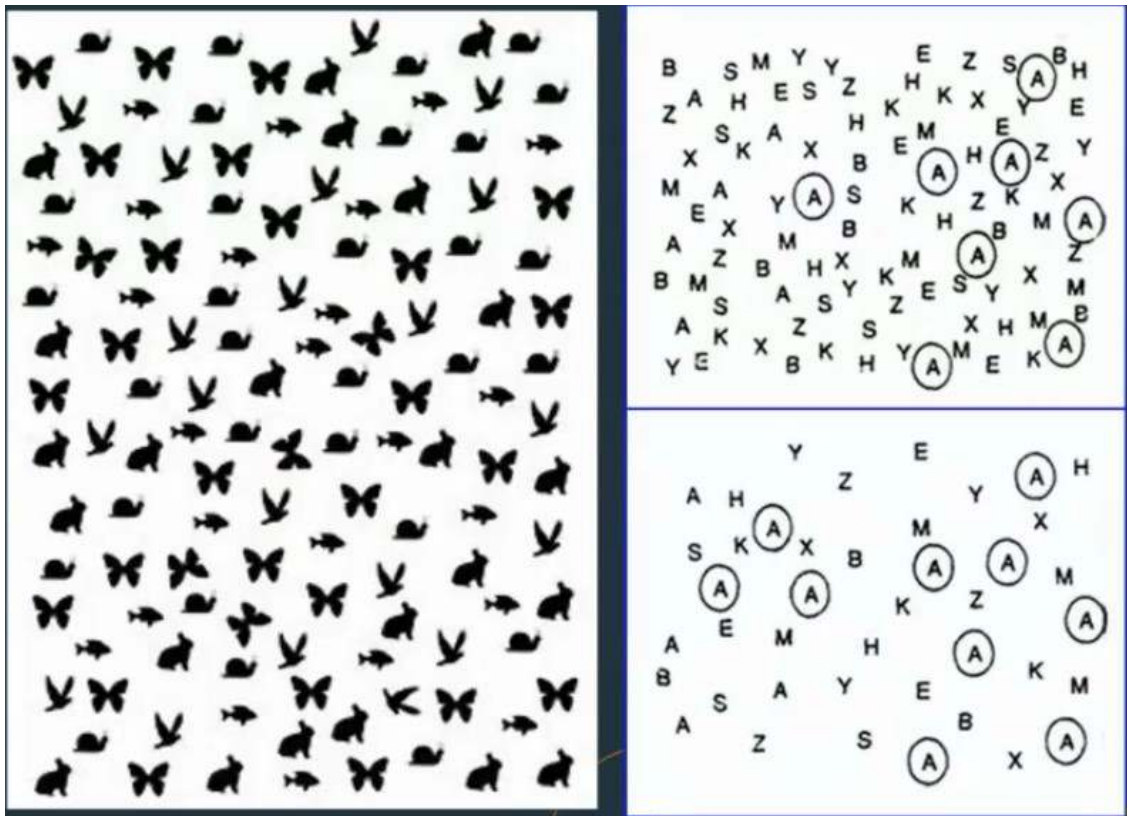
Plan of recovery.

1. **Acute phase**: We first look at making sure that the life-sustaining functions are intact and stable. Mostly done by neurosurgeons or neurologists
2. **Post acute phase**: After 7-12 weeks, helping the patient cope with their symptoms. Other specialists might also be involved in this phase. The psychoeducation part is where we come in, we would do tests or a battery of assessments to figure out the extent of the damage. Then we can tell the patient about the cognitive symptoms of traumatic brain injury.
3. **Chronic phase**: We start thinking about cognitive rehabilitation and it usually involves a team of people who decide what happens in the rehabilitation process. We start with one function like attention and move on to another function like memory. Helping with one function might improve other functions too. So this goal setting process is very important. It involves an integrated approach so that we can address symptoms and other comorbid conditions.


Acute (Immediately)
Life sustaining functions
Post Acute (7-12 weeks)
Management of symptoms affecting cognitive function such as headaches, vestibular disturbance, sleep difficulties, mood disturbance, fatigue and pain
Psychoeducation about cognitive symptoms of TBI
Brief and focused assessment and guidance about strategies for management of cognitive symptoms
Chronic (>12 weeks)
Evaluation for cognitive rehabilitation
Psychoeducation about cognitive rehabilitation
Multidisciplinary team involvement
Selection of functional rehabilitation targets and goals
Integrated holistic treatment including management of comorbid conditions

Examples of cognitive rehabilitation tasks

- **<u>Letter Cancellation (Attention)</u>**



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1. There are levels of difficulty (more crowded or we can get creative and choose a test where we can use other things, animals for example and ask the patient to circle the butterflies)

- **<u>Grain sorting and shading (Finger Dexterity)</u>**
    1. This is a home based rehabilitation task (because it's not always feasible to go to the hospital or rehabilitation center)
    2. In grain sorting, the patient has to sort grains based on their sizes. So we mix three grains like Channa, green gram or rajma and then ask them to sort it. Start with an easy level and then move up.
    3. Difficulty can be increased by adding other grains or increasing the quantity of grains. You can also set a time limit since you would know their baseline. We could also add smaller grains like rice or mustard.
    4. Other aspects like emotion should also be noticed.
    5. Shading: Giving the participant a shape (like a square or circle) and we ask the participant to shade within the lines.
    6. Difficulty can be increased by using more complex shapes

CogSMART protocols

These are rehabilitation strategies and procedures we can use with the tests to help the patient's symptoms. (1:19:00 in the 17th video)

Table 1.
Domains targeted in Cognitive Symptom Management and Rehabilitation Therapy (CogSMART) and their associated strategies.

Impaired Domain	Specific Compensatory Strategies and Habits Taught in CogSMART
Postconcussive Symptoms	Psychoeducation regarding natural course of postconcussive symptoms.
	Appropriate pacing, use of routines, and lifestyle strategies.
	Stress reduction (e.g., progressive muscle relaxation, abdominal breathing, mindfulness, visualization, grounding).
	Sleep hygiene education; headache management; and education regarding depression, anxiety, and posttraumatic stress disorder.
Prospective Memory	Daily calendar use.
	To-do lists and prioritizing tasks.
	Linking tasks and using "can't miss reminders" to cue tasks.
Attention and Vigilance	Conversational vigilance skills (reduce distractions, eye contact, paraphrasing, and asking questions).
	Task vigilance skills (paraphrase instructions, use self-talk during tasks to maintain focus).
Learning and Memory	Encoding strategies (write things down, paraphrasing/repetition, association, chunking, categorizing, acronyms, rhymes, visual imagery, name-learning strategies).
	Retrieval strategies (systematic searching) and organizational strategies for general learning and memory.
Executive Functioning	6-step problem-solving method (define problem, brainstorm solutions, evaluate solutions, select solution, try it, evaluate how it worked).
	Self-talk while solving problems.
	Hypothesis testing and self-monitoring.

1. **Postconcussive symptoms:** The patient is told about what to expect on their path to recovery and we make a realistic plan for them. Done in the post-acute phase
2. **Prospective memory:** Planning for the future i.e remembering tasks in the future. This is managed by making calendars, to do lists and prioritizing tasks. (like using sticky notes or using an app)
3. **Executive function**: For problem solving. Being aware of what they are doing through asking them to focus on self-task. Hypothesis testing is basically like we do our research. The patient can come up with a hypothesis and then test it. For example, the issue is that the patient is not very confident making independant purchases. So to test their confidence, we develop a hypothesis and test it by engaging in the process. We can come up with potential problems and solutions and such.
4. **Learning and memory:** Giving them strategies to help better their memory and learning skills
5. **Attention and vigilance:** Looks at social cognition.
   (1:32:00 in the 17th video: Attention task)

So this is what happens during rehabilitation:

1) Assessment
2) Understanding the patients needs
3) Develop a customised plan
4) Exercises for a better recovery

There are apps like Lumosity which aim to help in cognitive rehabilitation

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Neurofeedback:

- There are two screens :the front end and the back end
- The back end is monitored by the therapist to see the activity and the front end is usually a game that the patient plays. In NIMHANS, it's like a race between 4 bugs and by focusing on one of the bugs, you can make it move. You are told at the end if the object you focussed on won or not.
- An EEG cap is placed with electrodes at particular areas on the head which measures brain waves
- None of the data from the back end is given to the participant, only feedback about the game.

Table 1.

Specific brainwaves with their characteristics.

Common brainwave frequency	Frequency range (Hz)	General characteristics
Delta	1–4	Sleep, repair, complex problem solving, unawareness, deep-unconsciousness
Theta	4–8	Creativity, insight, deep states, unconsciousness, optimal meditative state, depression, anxiety, distractibility
Alpha	8–13	Alertness and peacefulness, readiness, meditation, deeply-relaxed
Lower alpha	8–10	Recalling
Upper alpha	10–13	Optimize cognitive performance
SMR (sensorimotor rhythm)	13–15	Mental alertness, physical relaxation
Beta	15–20	Thinking, focusing, sustained attention, tension, alertness, excitement
High beta	20–32	Intensity, hyperalertness, anxiety
Gamma	32–100 or 40	Learning, cognitive processing, problem solving tasks, mental sharpness, brain activity, organize the brain

- These frequencies are engaged in based on what we need to measure. We get live feedback and the game and software can be reworked based on what we need.
- NFT protocols are usually revised again in two weeks or so depending on the total number of sessions based on the progress.

The whole picture:

These processes are all used to see generalised improvement in everyday functioning.

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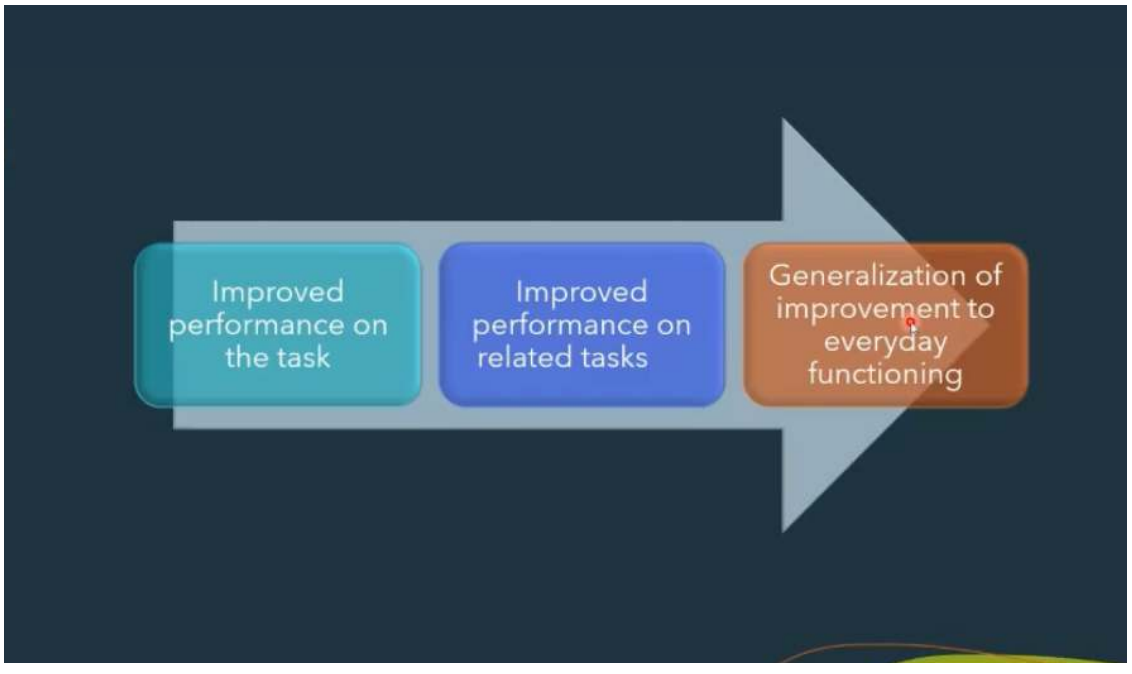
Improved performance on the task
Improved performance on related tasks
Generalization of improvement to everyday functioning

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